

Naval Postgraduate School
Monterey, California 93943-5138

NPS-09-02-021



SUMMARY OF RESEARCH 2001



**Department of Electrical and Computer Engineering
Graduate School of Engineering and Applied Sciences**

**Jeffrey B. Knorr
Chair**

**Murali Tummala
Associate Chair for Research**

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Prepared for: Naval Postgraduate School
Monterey, CA 93943-5000

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NAVAL POSTGRADUATE SCHOOL
Monterey, California

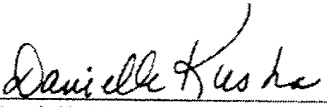
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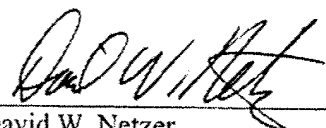
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THE NAVAL POSTGRADUATE SCHOOL MISSION

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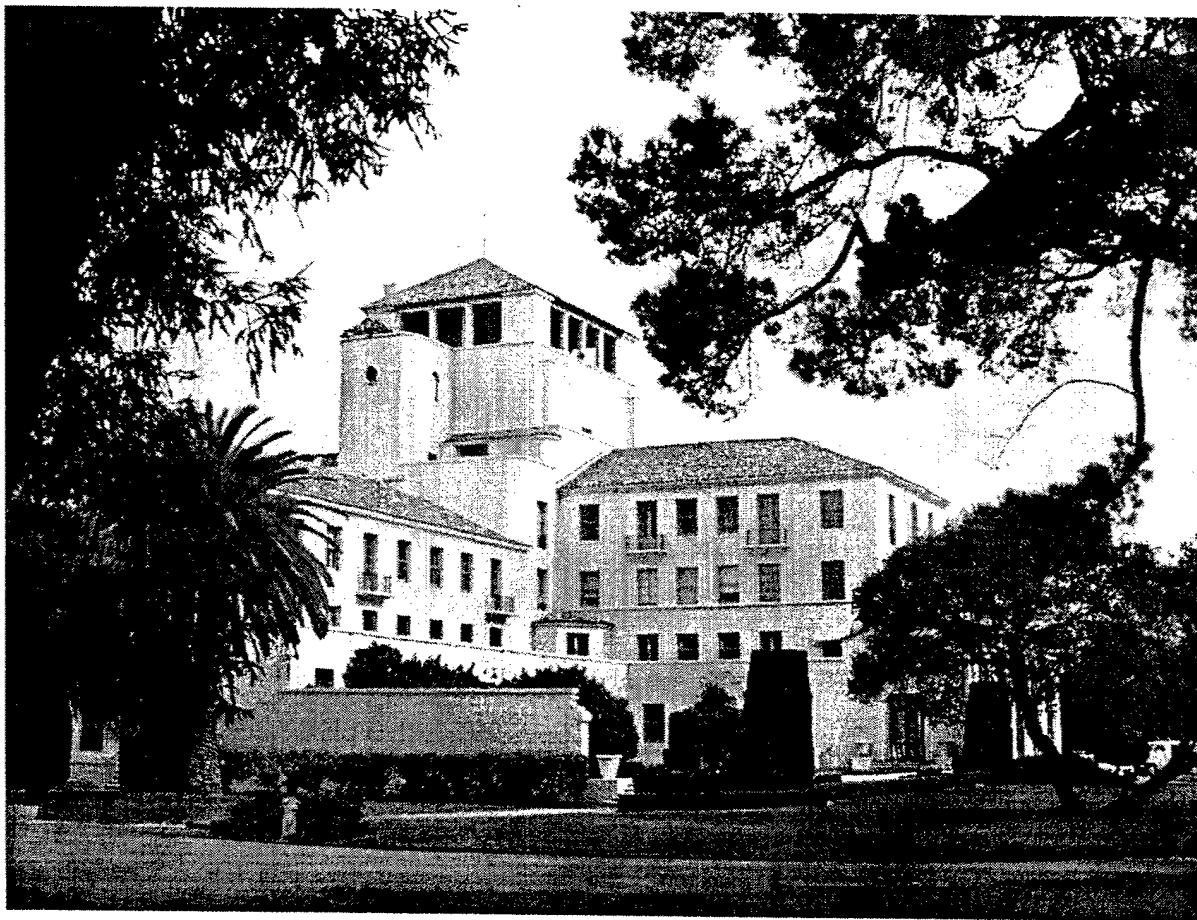


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PREFACE

Research at the Naval Postgraduate School is carried out by faculty in the four graduate schools (School of International Graduate Studies, Graduate School of Operations and Information Sciences, Graduate School of Engineering and Applied Sciences, and Graduate School of Business and Public Policy) and three Research Institutes (The Modeling, Virtual Environments, and Simulation (MOVES) Institute, Institute for Information Superiority and Innovation (I2SI), and Institute for Defense System Engineering and Analysis (IDSEA). This volume contains research summaries for the projects undertaken by faculty in the Department of Electrical and Computer Engineering during 2001. The summary also contains thesis abstracts for those students advised by Electrical and Computer Engineering faculty during 2001.

Questions about particular projects may be directed to the faculty Principal Investigator listed, the Department Chair, or the Department Associate Chair for Research. Questions may also be directed to the Office of the Associate Provost and Dean of Research. General questions about the Naval Postgraduate School Research Program should be directed to the Office of the Associate Provost and Dean of Research at (831) 656-2099 (voice) or research@nps.navy.mil (e-mail). Additional information is also available at the RESEARCH AT NPS website, <http://web.nps.navy.mil/~code09/>

Additional published information on the Naval Postgraduate School Research Program can be found in:

- *Compilation of Theses Abstracts:* A quarterly publication containing the abstracts of all unclassified theses by Naval Postgraduate School students.
- *Naval Postgraduate School Research:* A tri-annual (February, June, October) newsletter highlighting Naval Postgraduate School faculty and student research.
- *Summary of Research:* An annual publication containing research summaries for projects undertaken by the faculty of the Naval Postgraduate School.

This publication and those mentioned above can be found on-line at:
<http://web.nps.navy.mil/~code09/publications.html>.

INTRODUCTION

The research program at the Naval Postgraduate School exists to support the graduate education of our students. It does so by providing military relevant thesis topics that address issues from the current needs of the Fleet and Joint Forces to the science and technology that is required to sustain the long-term superiority of the Navy/DoD. It keeps our faculty current on Navy/DoD issues, and maintains the content of the upper division courses at the cutting edge of their disciplines. At the same time, the students and faculty together provide a very unique capability within the DoD for addressing warfighting problems. Our officers must be able to think innovatively and have the knowledge and skills that will let them apply technologies that are being rapidly developed in both the commercial and military sectors. Their unique knowledge of the operational Navy, when combined with a challenging thesis project that requires them to apply their focused graduate education, is one of the most effective methods for both solving Fleet problems and instilling the life-long capability for applying basic principles to the creative solution of complex problems.

The research program at the Naval Postgraduate School consists of both reimbursable (sponsored) and institutionally funded research. The research varies from very fundamental to very applied, from unclassified to all levels of classification.

- **Reimbursable (Sponsored) Program:** This program includes those projects externally funded on the basis of proposals submitted to outside sponsors by the School's faculty. These funds allow the faculty to interact closely with RDT&E program managers and high-level policymakers throughout the Navy, DoD, and other government agencies as well as with the private sector in defense-related technologies. The sponsored program utilizes Cooperative Research and Development Agreements (CRADAs) with private industry, participates in consortia with government laboratories and universities, provides off-campus courses either on-site at the recipient command, by VTC, or web-based, and provides short courses for technology updates.
- **Naval Postgraduate School Institutionally Funded Research (NIFR) Program:** The institutionally funded research program has several purposes: (1) to provide the initial support required for new faculty to establish a Navy/DoD relevant research area, (2) to provide support for major new initiatives that address near-term Fleet and OPNAV needs, (3) to enhance productive research that is reimbursably sponsored, and (4) to cost-share the support of a strong post-doctoral program.

In 2001, the level of research effort overall at the Naval Postgraduate School was 148 faculty work years and exceeded \$48 million. The reimbursable program has grown steadily to provide the faculty and staff support that is required to sustain a strong and viable graduate school in times of reduced budgets. In FY2001, over 93% of the research program was externally supported. A profile of the sponsorship of the Naval Postgraduate School Research Program in FY2001 is provided in Figure 1.

INTRODUCTION

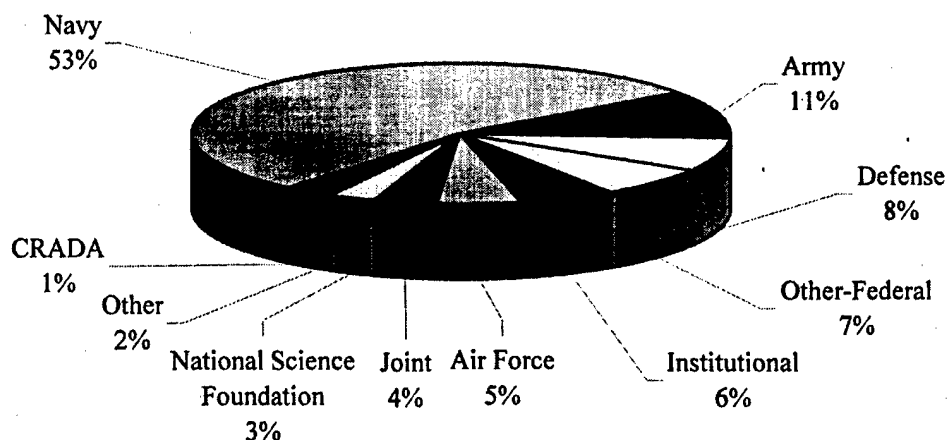


Figure 1. Profile of NPS Research and Sponsored Programs (\$52M)

The Office of Naval Research is the largest Navy external sponsor. The Naval Postgraduate School also supports the Systems Commands, Warfare Centers, Navy Labs and other Navy agencies. A profile of external Navy sponsorship for FY2001 is provided in Figure 2.

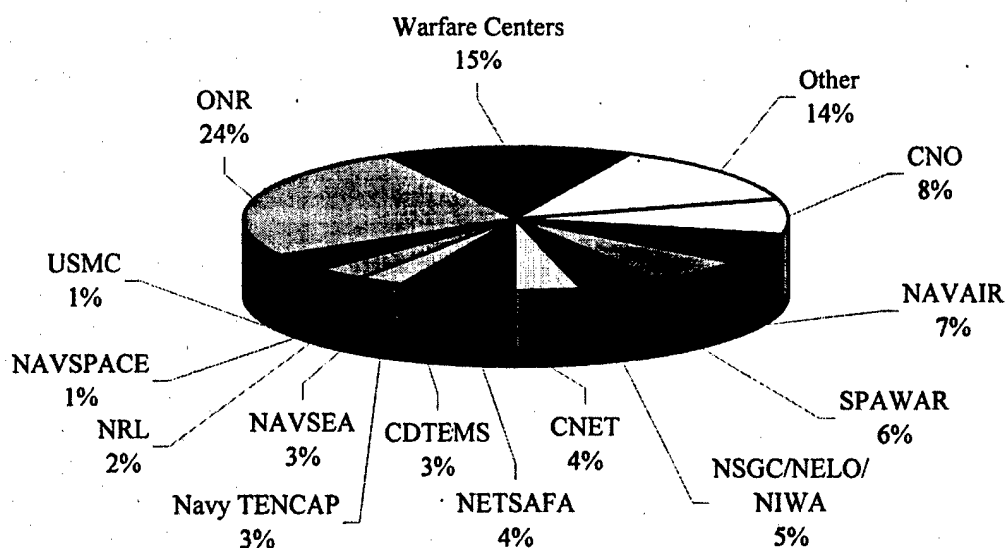


Figure 2. Navy External Sponsors of NPS Research and Sponsored Programs (\$29M)

These are both challenging and exciting times at the Naval Postgraduate School and the research program exists to help ensure that we remain unique in our ability to provide education for the warfighter.

DAVID W. NETZER
Associate Provost and Dean of Research

September 2002

**DEPARTMENT OF
ELECTRICAL AND COMPUTER
ENGINEERING**

**JEFFREY B. KNORR
CHAIR**

DEPARTMENT SUMMARY

OVERVIEW:

The Department of Electrical and Computer Engineering (ECE) has a broad research program, reflecting the variety of skills and interests of the faculty. ECE faculty research projects are supported by systems commands, warfare centers, the services, basic research agencies, other universities, and industry. These research projects can be grouped into ten major research thrust areas that support the curricula serviced by the Department as well as the several DoD Plans. Unique to the Department and the Naval Postgraduate School is the ability of faculty and students to perform military relevant classified research at all levels. The Department's research program ensures that our graduate students will have a creative and meaningful thesis experience, that our curricula and courses will remain at the cutting edge, that we can recruit and retain quality faculty, and that we can provide our sponsors with cutting edge solutions to their problems.

CURRICULA SERVED:

- Electronic Systems Engineering
- Information Warfare
- Electronic Warfare
- Space Systems Operations
- Space Systems Engineering
- Undersea Warfare
- Joint C4I Systems
- Information Technology Management
- Aeronautical Engineering

DEGREES GRANTED:

- Master of Science in Electrical Engineering
- Master of Science in Engineering Science
- Electrical Engineer
- Doctor of Philosophy

RESEARCH THRUSTS:

- Communication Systems:
Professor Tri Ha, Professor R. Clark Robertson
- Communication Networks:
Assistant Professor John McEachen, Professor Murali Tummala, Military Assistant Professor Robert Ives, Associate Professor Xiaoping Yun
- Computer/Information Systems:
Professor Jon Butler, Associate Professor Douglas Fouts, Professor Herschel Loomis, Visiting Instructor Randy Wight
- Electromagnetic Systems:
Professor Jeffrey Knorr, Research Associate Professor Richard Adler, Associate Professor David Jenn, Professor Michael Morgan, Research Associate Andrew Parker, Research Associate Professor Ray Vincent, Visiting Associate Professor Jovan Lebaric
- Infra-Red and Electro-Optics:
Distinguished Professor John Powers, Professor Phillip Pace, Visiting Associate Professor Ron Pieper
- Guidance, Control and Navigation Systems:
Associate Professor Roberto Cristi, Associate Professor Gary Hutchins, Associate Professor Xiaoping Yun
- Power Electronics, Electric Machines and Distribution:
Associate Professor Robert Ashton, Associate Professor John Ciezki

DEPARTMENT SUMMARY

- Radar, Surveillance and Information Warfare Systems:
Professor Jeffrey Knorr, Professor Phillip Pace, Research Associate Professor Lonnie Wilson, Professor R. Clark Robertson
- Signal Processing/Acoustic Systems:
Associate Professor Roberto Cristi, Associate Professor Monique Fargues, Associate Professor Ralph Hippenstiel, Professor Charles Therrien, Professor Murali Tummala, Professor Lawrence Ziomek
- Signals Intelligence/Space Systems:
Associate Professor Douglas Fouts, Professor Tri Ha, Associate Professor Ralph Hippenstiel, Professor Herschel Loomis, Assistant Professor John McEachen, Associate Professor Sherif Michael, Assistant Professor Todd Weatherford
- Solid State Microelectronics:
Associate Professor Douglas Fouts, Associate Professor Sherif Michael, Assistant Professor Todd Weatherford

RESEARCH FACILITIES:

- Signal Enhancement Lab
- Power Electronics Lab
- Digital Signal Processing Lab
- Electronics (Analog VLSI/Radiation Hardening) Lab
- Electronic Warfare Lab
- Electromagnetic Lab
- Optical Electronics Lab
- Robotics Lab
- Advanced Networking Lab
- VLSI Lab
- Secure Computing Lab

RESEARCH CENTERS:

- Center for Electronic Warfare Simulation and Modeling
- Center for Reconnaissance Research
- Center for Signal Processing
- Cryptologic Research Center
- Center for Radiation Hardened Electronics

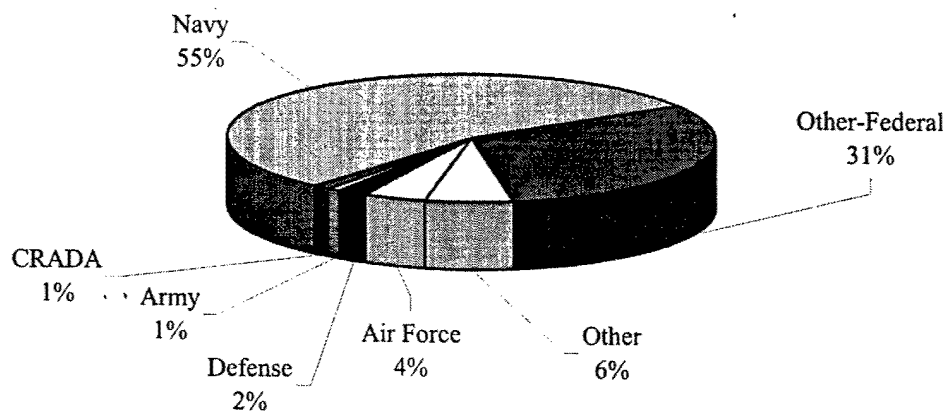
RESEARCH CHAIR:

- National Security Agency Cryptologic Chair

DEPARTMENT SUMMARY

RESEARCH PROGRAM (Research and Academic)-FY2001:

The Naval Postgraduate School's sponsored program exceeded \$49 million in FY2001. Sponsored programs included both research and educational activities funded from an external source. A profile of the sponsored program for the Department of Electrical and Computer Engineering is provided below:



Size of Program: \$3509K

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PROJECT SUMMARIES

NOISE AND INTERFERENCE AFFECTING THE PERFORMANCE OF EXISTING AND PROPOSED COMMUNICATION SYSTEMS

Richard W. Adler, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Federal Communication Commission

OBJECTIVE: To assess and report to the FCC the current state of knowledge about the electromagnetic noise and interference that affects the performance of existing and future wireless systems.

SUMMARY: The effort involves (1) a literature survey of the noise environment and (2) a preliminary definition of the modeling, simulation and measurement requirements for evaluating the effects of the noise on communication systems.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Radio Noise, Interference, Spectrum Signatures, Bibliographies

SIGNAL-TO-NOISE ENHANCEMENT PROGRAM

Richard W. Adler, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Security Group

OBJECTIVE: To define factors that adversely affect signal reception at receiving sites, determine the primary characteristics of factors, identify all factors, and provide recommendations for effective mitigation actions.

SUMMARY: Radio noise from overhead power lines has been identified as the major factor limiting the reception of radio signals at 36 of 37 sites examined. This little recognized factor is seriously limiting the effectiveness of HF, VHF, and UHF intercept systems to collect signals of special interest. The primary properties of this noise have been defined, source location procedures have been devised, and a means to identify source hardware has been generated. This effort has generated a number of technical papers and presentations during the last year. Some related work on signal reception in the microwave ISM bands has also been conducted.

PUBLICATIONS:

Parker, A.A., Adler, R.W. and Vincent, W.R., *Conducted EMI from an Engineering Model of a DC-to-DC Converter*, Naval Postgraduate School Technical Report, NPS-EC-01-007, June 2001.

PRESENTATIONS:

Vincent, W., Adler, R. and Munsch, G., "A Review of Man-Made Radio Noise at 37 HF Receiving Sites," Conference on Factors Affecting the Reception of Radio Signals, Naval Postgraduate School, 5-6 March 2001.

Vincent, W., Munsch, G. and Adler, R., "A Progress Report on a Model for Man-Made Noise at HF Receiving Sites," Conference on Factors Affecting the Reception of Radio Signals, Naval Postgraduate School, 5-6 March 2001.

Parker, A., Adler, R. and Vincent, W., "Spectrum Signatures of Man-Made Noise," Conference on Factors Affecting the Reception of Radio Signals, Naval Postgraduate School, 5-6 March 2001.

Vincent, W., Parker, A. and Adler, R., "Ambient Signals and Noise in the 915-MHz ISM Band," Conference on Factors Affecting the Reception of Radio Signals, Naval Postgraduate School, 5-6 March 2001.

PROJECT SUMMARIES

Vincent, W., Adler, R. and Munsch, G., "Operation of a 2.4 GHz Portable Phone with Noise From a Microwave Oven," Conference on Factors Affecting the Reception of Radio Signals, Naval Postgraduate School, 5-6 March 2001.

Vincent, W., Adler, R. and Munsch, G., "The Temporal and Spectral Properties of Radio Noise from a Microwave Oven," Conference on Factors Affecting the Reception of Radio Signals, Naval Postgraduate School, 5-6 March 2001.

OTHER:

Parker, A., Adler, R. and Vincent, W., "Parasitic Oscillations from an Active Television Antenna," prepared in cooperation with the Department of Oceanography.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Radio Noise, Interference, Spectrum Signatures

DEVELOPMENT OF ALGORITHMS SUPPORTING HARDWARE-IN-THE-LOOP CONTROL OF SYNCHRONOUS MACHINES

Robert William Ashton, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Surface Warfare Center - Carderock Division

OBJECTIVE: This research involves the creation of a DSP platform for developing and testing motor control algorithms. The platform will have hardware-in-the-loop testing capability. The Navy's interest in pursuing an electric drive solution for ship propulsion has enabled the consideration of novel approaches for controlling the inverter used for the propulsion motor. The proposed research seeks to aid in the developing tools and algorithms to support an initial reduced-scale proof-of-concept demonstration. The demonstration will utilize a three-phase permanent magnet synchronous machine powered by a conventional three-phase voltage source inverter. The investigation will execute a number of tasks, culminating in a set of deliverables.

DoD KEY TECHNOLOGY AREAS: Other (Motor Control)

KEYWORDS: PWM Inverter, Synchronous Machine, Vector Control, DSP

IMPLEMENTATION OF CLOSED-LOOP SYNCHRONOUS MACHINE CONTROL

Robert William Ashton, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Surface Warfare Center - Carderock Division

OBJECTIVE: The proposed research seeks to aid in hardware and software modifications to existing inverters so that various Navy motor loads may be utilized and tested. This research involves the implementation of closed-loop controls for synchronous machines utilizing multiple inverters of varying power levels to drive Navy motor loads up to 400HP. The Navy's interest in pursuing an electric drive solution for ship propulsion has enabled the consideration of novel approaches for controlling the inverter used for the propulsion motor and other motor loads. The drive system will be demonstrated utilizing three-phase induction or synchronous machines powered by multiple synchronized three-phase inverters. The investigator will execute a number of tasks, culminating in a set of deliverables.

DoD KEY TECHNOLOGY AREAS: Other (Motor Control)

KEYWORDS: PWM Inverter, Synchronous Machine, Vector Control, DSP

PROJECT SUMMARIES

INTEGRATED FIGHT-THROUGH POWER AND ADVANCED POWER CONVERTER MODULES

Robert William Ashton, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Surface Warfare Center - Philadelphia

OBJECTIVE: The proposed research seeks to aid in developing tools and algorithms to support an initial reduced-scale proof-of-concept demonstration.

SUMMARY: This research involves the creation of a DS platform for developing and testing motor control algorithms. The platform will have hardware-in-the-loop testing capability. The Navy's interest in pursuing an electric drive solution for ship propulsion has enabled the consideration of novel approaches for controlling the inverter used for the propulsion motor. The demonstration will utilize a three-phase permanent magnet synchronous machine powered by a conventional three-phase voltage source inverter. The investigation will execute a number of tasks, culminating in a set of deliverables.

This research involves the engineering design of advanced power conversion modules under current Navy development. This task will require the investigation of available power converter design options. Additionally, assistance in the design and development of advanced reconfigurable zonal electric distribution system hardware will be provided in the form of testing, debugging and documentation. Support includes conducting appropriate tests, analyzing/evaluating technical documentation/data, and providing comments. The principal investigator shall attend technical meetings, as required, and provide monthly status reports. Travel to CDNSWC-SSES Philadelphia shall be required to implement the above objectives.

This research concentrated on specific issues surrounding the Land Based Engineering Site (LBES) in Philadelphia. The investigator was tasked with the evaluation of data from test runs for a number of Power Converter Modules (PCM) ranging from 250kW to 19MW. Test results were analyzed and used by the investigator to aid in making recommendations for future PCMs. In addition, three specific failure events took place on the 19MW PWM electric drive unit. Each event was analyzed using the available data including forensics on the components. Reports and presentations were made in Philadelphia and Rugby, England. The results of the investigation have been utilized in redesign efforts by the vendor.

DoD KEY TECHNOLOGY AREAS: Other (Electronic Devices, Energy Conversion)

KEYWORDS: Power System, Auxiliary Resonant Commutated Pole Inverter, PWM Inverter, Synchronous Machine, Vector Control, DSP

DESIGN ALGORITHMS FOR SUM-OF-PRODUCTS EXPRESSIONS

Jon T. Butler, Professor

Department of Electrical and Computer Engineering

Tsutomu Sasao, Kyushu Institute of Technology, Japan

Sponsor: Unfunded

OBJECTIVE: To produce design algorithms for digital logic circuits using sum-of-products expressions.

SUMMARY: The design of many logic circuits relies on the simplification of sum-of-products expressions that describe the function realized by the circuit. Efforts this year focused on three aspects of this problem. First, work continued from last year on bi-decomposition of functions. Last year, orthodox functions were identified as a special class of functions for which an efficient divide-and-conquer algorithm produces minimal sum-of-products expressions. This year, collaborative work with NPS Master's student, Birol Ulker, identified families of non-orthodox functions in. Second, shared binary decision diagrams (SBDDs) were successfully applied to multi-output functions, and it was shown that this results in an improvement in circuit compactness of 16%, on the average, over standard binary decision diagram techniques. Third, a new type of programmable logic device was proposed and a study of efficient algorithm for these devices has been initiated. This is collaborative work with Professor Tsutomu Sasao of the Kyushu Institute of Technology.

PROJECT SUMMARIES

PUBLICATIONS:

Matsuura, M., Sasao, T., Butler, J.T. and Iguchi, Y., "Bi-partition of Shared Binary Decision Diagrams," Workshop on Synthesis and System Integration of Mixed Technologies (SASIMI-2001), pp. 172-177, Nara, Japan, 18-19 October 2001.

Sasao, T. and Butler, J.T., "Worst and Best Sum-of-Products Expressions," *IEEE Transactions on Computers*, pp. 935-948, September 2001.

Sasao, T. and Butler, J.T., "On the Minimization of SOPs for Bi-Decomposable Functions," ASP-DAC (Asian Southern Pacific Design Automation Conference), pp. 219-224, Yokohama, Japan, February 2001.

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Digital Systems, Compact Circuits, Computer-Aided Design Tools, Sum-of-Products Expressions

REED-MULLER CANONICAL EXPANSIONS OF LOGIC FUNCTIONS

Jon T. Butler, Professor

Department of Electrical and Computer Engineering

G.W. Dueck, University of New Brunswick, Canada

Sponsor: Unfunded

OBJECTIVE: To improve synthesis techniques for the Reed-Muller canonical representation of logic function.

SUMMARY: The Reed-Muller canonical expansion of a logic function uses the Exclusive OR of product terms, where each product term is the AND of variables or their complements. It has been shown that this representation requires fewer product terms, on the average, than standard sum-of-products expressions. The transeunt triangle concept that was introduced earlier has been extended to efficiently realize totally symmetric functions so that it also applies to partially symmetric functions. Efforts have also been expanded to the more general "inconsistent" expansion of functions proposed more than 30 years ago by Martin Cohn. In a collaborative effort with NPS student, Panos Michalopoulos, progress has been made in the understanding of the largest size one can possibly expect of functions in this form.

PUBLICATIONS:

Butler, J.T., Dueck, G.W., Yanushkevich, S.N. and Shmerko, V.P., "On the Number of Generators for Transeunt Triangles," *Discrete Applied Mathematics*, Vol. 108, pp. 309-316, 2001.

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Digital Systems, Compact Circuits, Computer-Aided Design Tools, Exclusive OR Sum-of-Products Expressions, Reed-Muller Canonical Expressions

COMPONENT MODELING AND SIMULATION EFFORTS FOR A PROPOSED LHD-8 AC ZONAL DISTRIBUTION SYSTEM

John G. Ciezki, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Surface Warfare Center - Carderock Division

OBJECTIVE: The Navy is currently designing the next-generation LHD amphibious ship. Innovations are being proposed for the power distribution system, including zonal AC and a hybrid electric drive. Models of the components and interconnected system topologies are required to analyze the system for

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fault performance, stability, circuit breaker response, and the design of paralleling controls. The enclosed effort requires the development and integration of component-level models into an existing AC zonal distribution package. Specifically, the existing package will be reviewed for syntax and interconnection format. Models for the diesel generators, delta-delta 3-phase transformers, synchronous machines, and associated controls will be formulated. Interconnection requirements will be documented.

SUMMARY: A literature search was conducted regarding diesel engine modeling and several strategies were investigated. Modeling equations for the delta-delta transformers and conventional three-phase synchronous machines were formulated. An interconnection strategy was developed based on Mayer's approach of root and non-root models. Control development software was written to aid in the tuning of exciter parameters. Woodward control diagrams were consulted for current topologies. Software implementation was hampered by UNIX system incompatibilities and system administrator delays. Work continues on delivering operational models.

DoD KEY TECHNOLOGY AREAS: Surface/Under Surface Vehicles – Ships and Watercraft

KEYWORDS: AC Zonal Distribution, Diesel Generators, Transformers, ACSL Simulation

DETAILED FAULT CHARACTERIZATION FOR SHIPBOARD POWER SYSTEMS

John G. Ciezki, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Surface Warfare Center - Carderock Division

OBJECTIVE: The performance of Navy shipboard power systems during casualty situations is critical in assessing survivability and in formulating improved condition monitoring hardware and control algorithms. Power system damage inflicted by mines, air-to-surface missiles, and other projectiles is manifested in various types of cable short circuits and open circuits. The damage can appear intermittently and it can cascade if monitoring systems are not able to isolate fault locations quickly. The purpose of this work is to develop computer representations of various fault scenarios and match the models to acquired test facility data. This effort entails modeling the test facility generator, developing circuit equations to represent line-line and various fault conditions, including both low impedance and high impedance faults, and modifying the fault impedance representation in a time-varying fashion in order to match the collected data.

SUMMARY: A literature review was conducted on techniques used for characterizing time-varying fault impedances. Parameters for the synchronous machine test facility were calculated via test data information. Equations were developed modeling single-phase, phase-to-phase, and three-phase faults for a conventional three-phase machine. Studies were devised for contrasting the ACSL simulations with available KEMA test data. Simulations results have been delayed due to the inability of UNIX administrators to install and get the ACSL software running. Work continues on providing useful deliverables.

DoD KEY TECHNOLOGY AREAS: Surface/Under Surface Vehicles – Ships and Watercraft

KEYWORDS: Fault Analysis, AC Generators, ACSL Simulation

SYMBOLIC MATHEMATICS FOR ON LINE TESTING

Roberto Cristi, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Unfunded

OBJECTIVE: The purpose of this research is to develop tools for on line testing techniques which are not multiple choice. This will benefit courses in the Applied Sciences areas (Engineering, Mathematics, Physics), where the answers of the students are formulated in terms of mathematical symbols.

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SUMMARY: The use of symbolic evaluation software, such as Mathematica, provides the necessary engine for evaluating and assessing the student's responses. The outcomes of this research are presented in J. Biggs' master's thesis and a Website (<http://pclearn.ece.nps.navy.mil>) of a Digital Signal Processing Course (EC2400, currently in the NPS catalog) has been developed. In J. Biggs' thesis, a general architecture for on-line course development is presented. In particular it is shown that by a combination of a number of software tools (JSP, Servlets, Mathematica, WebMathematica and Access), an on-line course can be developed which is capable not only of evaluating student's answers entered in symbolic form, but also of tracking the student's performance in the course. The latter is achieved by a dynamic test, which adapts the questions in the exams to the student's performance. According to this scheme, the student is evaluated on the basis of a number of trials necessary to answer a number of similar questions. In this way the evaluation is not binary (just right or wrong) and it rules out the possibility of guessing. The software developed is also capable of delivering coursework material, keep track of student enrollment, and appropriately schedule tests for the students.

THESIS DIRECTED:

Briggs, J., "Web Testing Tools for Electrical Engineering Courses," Masters Thesis, Naval Postgraduate School, September 2001.

DoD KEY TECHNOLOGY AREA: Manpower, Personnel and Training

KEYWORDS: On-line Course, Digital Signal Processing

FEATURE EXTRACTION FOR SIGNAL CHARACTERIZATION IN CLASSIFICATION APPLICATIONS: APPLICATIONS TO COMMUNICATION MODULATION

Monique P. Fargues, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Center for Reconnaissance Research

OBJECTIVE: This study completed an on-going research effort investigating various feature extraction schemes and applications to the classification of digital signal modulation types.

SUMMARY: The study conducted during FY01 concluded an on-going research effort investigating feature extraction schemes and applications to the classification of digital modulation schemes. The study was split into two phases.

First, a hierarchical tree-based classification approach was considered to the classification of digital modulation schemes of types [2,4,8]-PSK, [2,4,8]-FSK and [16,64,256]-QAM in low SNR levels and multipath propagation channel conditions, where back-propagation neural network units were adopted at each tree node. Higher-order statistics-based class features were investigated and a small number of cumulants and moments chosen to differentiate between all various types of modulation types, except for specific M-QAM types. While being part of the hierarchical procedure, the identification of specific M-QAM types was conducted via equalization algorithms. Extensive simulations show overall classification performances to be strongly affected by the amount of multipath distortion and noise in the transmission channels.

The second phase of the study investigated three discriminant-based feature dimension reduction schemes: the Mean Separator Neural Network (MSNN), the Mahalanobis-based Dimension Reduction scheme (MBDR), and the kernel-based Generalized Discriminant Analysis (GDA) approach. PCA was also included for comparison purposes. All four feature dimension reduction schemes were implemented and evaluated by applying the transformed features to a basic minimum distance classifier. Three classification datasets commonly used in statistics for benchmarking purposes were selected for benchmarking purposes. Results showed the kernel-based generalized discriminant analysis approach to lead to consistently higher classification performances than the other schemes considered in the study for the data investigated.

PROJECT SUMMARIES

PUBLICATIONS:

Fargues, M.P. and Hatzichristos, G., "A Hierarchical Approach to the Classification of Digital Modulation Types in Multipath Environments," *Proceedings of the 35th Asilomar Conference on Signals, Signals, and Computers*, November 2001.

Fargues, M.P., *Investigation of Feature Dimension Reduction Schemes for Classification Applications*, Naval Postgraduate School Technical Report, NPS-EC-01-005, June 2001.

Fargues, M.P. and Hatzichristos, G., *A Hierarchical Approach to the Classification of Digital Modulation Types in Multipath Environments*, Naval Postgraduate School Technical Report, No. NPS-EC-01-004, May 2001.

THESIS DIRECTED:

Hatzichristos, G., "Classification of Digital Modulations in Multipath Environments," Masters Thesis, Naval Postgraduate School, March 2001.

DoD KEY TECHNOLOGY AREAS: Electronics, Computing and Software

KEYWORDS: Classification, Higher-Order Statistics, Kernel Method

DETECTION, CLASSIFICATION AND PROCESSING OF WIRELESS LOCAL AREA NETWORK SIGNALS

Tri T. Ha, Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Information Warfare Activity

OBJECTIVE: Develop a prototype using commercially available low cost hardware and software solutions to detect, classify and process a wireless IEEE 802.11b DSS compliant network signal.

SUMMARY: There were routine interactions (through phone conversations, email, meetings, etc.) with the staff, students, government agency and contractor personnel involved in this NIWA sponsored project. This research focuses on developing a prototype system that will allow the detection and process WLAN signals in real time. The prototype system was developed using commercial software and hardware components that can be upgraded and enhanced as the industry standard changes. The research includes the methodology used in selecting the commercial software and hardware components. In addition substantial testing results are included that outline the conditions under which the prototype will be able to receive and process 802.11b WLAN signals. The measured data is compared to radio frequency propagation models, and a simple formula to determine if a signal can be detected is presented. The research concludes with recommendations on how to successfully employ the system in an operational environment.

DoD KEY TECHNOLOGY AREAS: Other (Information Operations, Electrical Engineering)

KEYWORDS: WLAN, Propagation Model, Wireless

NSA/ATD CRYPTOLOGIC RESEARCH LAB AND THESIS RESEARCH SUPPORT

Tri T. Ha, Professor

Department of Electrical and Computer Engineering

Sponsor: National Security Agency

OBJECTIVE: Support for the Cryptologic Research Lab at the Naval Postgraduate School wherein graduate students perform research in support of ATD (formerly K51).

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SUMMARY: The Cryptologic Research Laboratory, sponsored by the National Security Agency's ATD, is a valuable resource which provides a cost effective, viable and robust research platform for NPS graduate students and faculty in Electrical Engineering, Information Warfare, and Computer Science and related curricula. It offers an unclassified environment wherein graduate students can develop an in-depth understanding of cryptology and related disciplines by researching capabilities, limitations, design, and operations of digital signal processing and exploitation techniques, satellite communications technologies, cellular technologies, wireless communications and other analogous cryptologic areas.

THESES DIRECTED:

Halloran, S.P., "Vulnerability Assessment Through Predictive Modeling of IEEE 802.11 Standard Wireless Local Area Networks," Masters Thesis, Naval Postgraduate School, June 2000.

Myers, W.S., "Exploitation of an IEEE 802.11 Standard Wireless Local Area Network Through the Medium Access Control (MAC) Layer," Masters Thesis, Naval Postgraduate School, June 2000.

Oubre, D.I., "Capabilities and Limitations of Orthogonal Frequency-Division Multiplexing in Wireless Applications," Masters Thesis, Naval Postgraduate School, September 2000.

Harrell, A.T., "Wireless Technology Via Satellite Communications for Peacekeeping Operations," Masters Thesis, Naval Postgraduate School, September 2000.

Yokoyama, M.K., "Airborne Exploitation of an IEEE802.11b Wireless Local Area Network," Masters Thesis, Naval Postgraduate School, September 2000.

Count, P.A., "Performance Analysis of OFDM in Frequency Selective, Slowly Fading Nakagami Channels," Masters Thesis, Naval Postgraduate School, December 2000.

DoD KEY TECHNOLOGY AREAS: Other (Information Operations, Electrical Engineering)

KEYWORDS: Cryptology, Exploitation, Wireless

IMPROVEMENT OF THE SIGNAL-TO-NOISE RATIO USING WAVELET RELATED SIGNAL PROCESSING

Ralph D. Hippenstiel, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Center for Reconnaissance Research

OBJECTIVE: Investigate wavelet related processing and scale/time tiling to improve the effective SNR of signatures of interest.

SUMMARY: The work investigates the improvement of the estimate of signals which are embedded in white Gaussian noise. The first part evaluates the use of a wavelet based decomposition to denoise signals. The denoising is achieved in the wavelet domain using i) median and ii) predictive filtering. The second part focuses on the use of Fourier transform based denoising, where the denoising is applied in the time-frequency domain. The denoising uses median or predictive filtering. Improvement is measured using the mean square error.

THESES DIRECTED:

Hughes, J., "Signal Enhancement Using Time-Frequency Based Denoising," Masters Thesis, Naval Postgraduate School, in progress.

Kan, H.E., "Signal Enhancement," Masters Thesis, Naval Postgraduate School, in progress.

PROJECT SUMMARIES

DoD KEY TECHNOLOGY AREA: Electronics

KEYWORDS: Signal Enhancement, Signal Classification, Wavelet Based Decomposition, Denoising, Time-Frequency Based Filtering

DEFENSE TECHNOLOGY AND SYSTEMS COURSE

David C. Jenn, Associate Professor

Department of Electrical and Computer Engineering

Sponsors: National University of Singapore

OBJECTIVE: Generate and deliver a comprehensive set of lectures that cover the topics of basic electromagnetics, transmission lines, antennas, propagation, scattering, radar, jamming, and sensor integration and fusion. Design a set of computer based laboratory exercises based on the lecture material. The total length of the course is four days and two exams are given to evaluate student performance.

SUMMARY: Lecture notes were based on the material in NPS courses EO2652, EO3602 and EO4612. The notes were initially generated for last year's course, but significant modifications were required for this year's course. The course also uses a set of Matlab based computer exercises for instruction in each of the topic areas.

PUBLICATIONS: "Sensors," 13 volume set of lecture notes (352 pages) in PDF format.

PRESENTATIONS: DTSC lectures and laboratory supervision (4 days).

DoD KEY TECHNOLOGY AREA: Electronic Warfare, Sensors, Electronics

KEYWORDS: Antennas, Electromagnetics, Sensors

EFFECTIVENESS OF BROADBAND ANTENNA DESIGNS

David C. Jenn, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: QRC, Inc.

OBJECTIVE: Several broadband antenna designs were evaluated for use in a ground penetrating radar for buried ordnance detection.

SUMMARY: A combination of measurement, analysis, and simulation was used to evaluate several antennas for use in a ground penetrating radar for the detecting buried ordnance (mines and unexploded bombs). Candidate antennas included the contra-wound helix, contra-wound log-periodic spiral and a sinuous cavity backed slot. A method-of-moments computer code was used to evaluate the antenna input impedance and near field patterns.

PUBLICATION:

Jenn, D.C. and Wollny, W.T., "Broadband Focused Radar at Ground Penetrating Frequencies for Detecting Mines," Final Report submitted to Army Research Office, Mechanical and Environmental Sciences Division, Engineering Sciences Directorate, November 2001.

PRESENTATION:

Jenn, D.C. and Wollny, W.T., "Broadband Antenna Study for Buried Object Detection," Army Research Office, Ft. Belvoir, 12 October 2001.

PROJECT SUMMARIES

DoD KEY TECHNOLOGY AREAS: Electronic Warfare, Sensors, Electronics

KEYWORDS: Antennas, Electromagnetics, Sensors

HELICOPTER PAYLOAD PHASE 1 ANTENNA STUDY

David C. Jenn, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: The objective of this study was to determine the optimum antenna placement given the available locations on the helicopter. The suitability of a location is determined by the quality of the antenna pattern, primarily field-of-view, which is defined as the range of angles over which the antenna gain is constant enough and/or sufficient enough to permit signal reception regardless of the direction of flight.

SUMMARY: An analysis and simulation of the antenna installed on the helicopter was conducted using computational electromagnetics (CEM) codes. The simulated pattern data for the installed antenna was compared to that of the free standing antenna, which is used as a baseline from which to determine the effects of the antenna placement on signal reception. If the installed antenna pattern deviates significantly from the baseline antenna pattern, then the reception is potentially degraded. The frequency range of interest was 100 MHz to 1200 MHz.

PUBLICATION:

Jenn, D.C., *Helicopter Payload Phase 1 Antenna Study*, Naval Postgraduate School Technical Report, NPS-EC-01-008, October 2001.

PRESENTATION:

Jenn, D.C., "VTUAV Phase 1 Antenna Study Results," VTUAV Program Review, Northrop-Grumman-Ryan Aerospace, San Diego, CA, 21 June 2001.

DoD KEY TECHNOLOGY AREA: Electronic Warfare, Sensors, Electronics

KEYWORDS: Antennas, Electromagnetics, Sensors

DAR REMOTE SENSING

Jeffrey B. Knorr, Professor

Department of Electrical and Computer Engineering

Bob Bluth, Research Associate

Center for Remotely Piloted Aircraft Studies

Sponsor: Office of Naval Research

OBJECTIVE: The objective of this project is to acquire and modify two military radars for meteorological research.

SUMMARY: An Army AN/MPQ-64 Sentinel radar was acquired in the Spring of 1999 and was brought to operational status during the Fall of 1999 and the Winter of 2000. An SBIR project, N01-035, Weather Processor for Rapid Scanning Tactical Radars, was initiated with ProSensing, Amherst, MA to add a Doppler processor to the radar for severe storm research. During May 2001, a meeting was held with ProSensing engineers to discuss details associated with the addition of the weather processor. It is expected that initial testing of the processor will take place during 2002.

During 2000 steps were also taken to obtain an Army AN/TPQ-37 Firefinder radar. A radar was delivered in the Spring of 2001 but the Army subsequently requested that the radar be returned to satisfy

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another requirement and it was relinquished in the Fall of 2001. The AN/TPQ-37 radar is similar to the AN/SPY-1 radar installed on the Navy's Aegis cruisers and destroyers. A project was planned to add a weather processor to this radar so it could be used as a testbed for investigation of AN/SPY-1 algorithms to extract meteorological data. This goal must now await the acquisition of another AN/TPQ-37 radar.

The overall long term objective of this project is to develop radar remote sensing capabilities that will provide meteorological data that can be used to describe weather phenomena, particularly in support of air operations in the fleet battlespace.

PRESENTATION:

Knorr, J.B., Bluth, R. and Pazmany, A., "Rapid Scan 3D Volumetric Weather Radar," 30th International Conference on Radar Meteorology, Munich, Germany, 14-19 July 2001.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Sensors

KEYWORDS: Remote Sensing, Radar Meteorology

ANTENNA DEVELOPMENT FOR MAN-PACK TACTICAL RADIOS

Jovan Lebaric, Visiting Associate Professor

Richard Adler, Research Associate Professor

Department of Electrical and Computer Engineering

Sponsor: U.S. Army Soldier Biological Chemical Command

OBJECTIVE: The objective is to improve the design a conformal, wearable RF vest antenna for low VHF, and to design a compact antenna for a hand-held field radio operating in the 30 to 88 MHz band.

SUMMARY: The research, development and design will be accomplished by optimizing the antenna and feed region shape, adding commercially available cladding material in the feed region, and integrating the RF vest with the Kevlar flak vest. The feed region cladding and shaping will reduce the near-field coupling to the operator and increase the antenna efficiency. The compact antenna design will be directed towards using dielectric and resistive loading to reduce the antenna VSWR while maintaining antenna radiation efficiency as high as possible.

PUBLICATION:

Lebaric, J., Adler, R.W. and Limbert, M., "Ultrawideband, Zero Visual Signature RF Vest Antenna for Man-Portable Radios," MILCOM 2001, McLean, VA, 28-31 October 2001.

PRESENTATION:

Lebaric, J., Adler, R.W. and Limbert, M., "Ultrawideband, Zero Visual Signature RF Vest Antenna for Man-Portable Radios," MILCOM 2001, McLean, VA, October 2001.

OTHER:

The NPS IP counsel has been informed that patent for "The Wearable Ultrawideband Vest Antenna" will be issued by the USPTO within a couple of months.

THESIS DIRECTED:

Limbert, M., "Ultrawideband Combat Wearable Integrated (COMWIN) Antenna Design for the Joint Tactical Radio System (JTRS)," Masters Thesis, Naval Postgraduate School, September 2001.

PROJECT SUMMARIES

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Communications, Antennas

DESIGN AND PROTOTYPING OF WIDEBAND USQ-113 ANTENNA FOR EA-6B

Jovan Lebaric, Visiting Associate Professor

Richard Adler, Research Associate Professor

Andrew Parker, Research Associate

Department of Electrical and Computer Engineering

Sponsor: Naval Air Systems Command

OBJECTIVE: Design and prototype an ultrawideband antenna for the USQ-113 system onboard EA-6B aircraft, such as to meet the specifications, especially height imposed by the operational aircraft use (carrier landing and take-off).

SUMMARY: This design is an evolution of the "bell" antenna design tested at NPS in FY99. The new design has a reduced height and weight, a modified shape, and addition of new elements. The design is a compromise between the optimal electrical performance for a given height constraint and the aerodynamic constraint of the high-speed platform the antenna is intended for.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Information Warfare, Jamming, Antennas

HELMET MOUNTED UHF ANTENNA FOR SATELLITE COMMUNICATIONS

Jovan Lebaric, Visiting Associate Professor

Richard Adler, Research Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: The objective is to design a satellite communications antenna for integration with a standard-issue U.S. military helmet, within DoD Instruction 605.11 defined parameters.

SUMMARY: The objective will be accomplished using a conformal two-arm spiral antenna design for circular polarization. The spiral will be embedded in a protective layer that would also increase the electrical length of the antenna. A shorted ring will be added at the bottom of the conformal two-arm spiral to improve the front-to-back ratio and reduce the operator near-field exposure below the levels specified in the DoD 605.11 standard.

THESIS DIRECTED:

Gibbs, D., "Design of Mobile User Objective System (MOUS) Helmet Mounted UHF Antenna," Masters Thesis, Naval Postgraduate School, September 2001.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Satellite Communications, Antennas

PROJECT SUMMARIES

USQ-146 LOW-PROFILE OMNI-DIRECTIONAL ULTRA-WIDEBAND ANTENNA FOR SHIPBOARD AND VEHICULAR USE

**Jovan Lebaric, Visiting Associate Professor
Richard Adler, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Information Warfare Activity**

OBJECTIVE: The objective is to design a low-profile omni-directional ultrawideband antenna for the USQ-146 system. The antenna will be installed on land-based vehicles or onboard ships.

SUMMARY: The antenna design is based on the mono-conical antenna with matched loading to reduce the antenna VSWR at the low end, with minimum reduction in antenna efficiency throughout the operating frequency range. Also, the design allows for increasing the antenna height using elements stowed inside the cone and deployed "on-demand."

THESIS DIRECTED:

Koutras, N., "Ultra-Wideband Antenna Designs for Military Vehicle Applications," Masters Thesis, Naval Postgraduate School, March 2001.

OTHER: Patent application submitted to NPS IP Counsel.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Information Warfare, Jamming, Antennas

USQ-146 LOW-PROFILE QUADRANT-SWITCHABLE-BEAM ULTRA-WIDEBAND ANTENNA FOR SHIPBOARD AND VEHICULAR USE

**Jovan Lebaric, Visiting Associate Professor
Richard Adler, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Information Warfare Activity**

OBJECTIVE: The objective is to design a low-profile ultra-wideband transmit antenna with steerable beams for the USQ-146 Rubicon system. The antenna would be used in a shipboard environment or land-based vehicle.

SUMMARY: The design objectives will be accomplished by employing a mono-cone and bi-cone designs with special loading such that directional properties are obtained. Mechanical rotation of the loading element provides for beam steering. The directivity is a function of frequency, above 10 dB from most of the operating range. The loading material can have a loss component added for the "out-of-band" RCS reduction.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Information Warfare, Jamming, Antennas

PROJECT SUMMARIES

ULTRA-WIDEBAND ANTENNA FOR THE USQ-146 INSTALLATION IN THE H-60 HELICOPTER

Jovan Lebaric, Visiting Associate Professor

Richard Adler, Research Associate Professor

Andrew Parker, Research Associate

Department of Electrical and Computer Engineering

Sponsor: Naval Information Warfare Activity

OBJECTIVE: The objective is to design, fabricate and test an ultra-wideband transmit antenna for the USQ-146 installation in the H-60 helicopter.

SUMMARY: The platform operational restrictions on landing and take-off restrict the design to a height of only 10 inches while the operational requirements call for an ultrawideband antenna capable of efficient operation at low frequencies where the permissible antenna height becomes a very small fraction of the operating wavelength. Several approaches have been investigated. One approach led to an antenna design such that the antenna is mechanically rotated into the operating position from a stowed position that satisfies the height constraint. Another design is currently under development for an ultrawideband antenna with no moving parts.

THESIS DIRECTED:

Adams, J., "Ultrawideband Antenna Design for the USQ-146 Installation for the H-60 Helicopter," Masters Thesis, Naval Postgraduate School, September 2001.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Information Warfare, Jamming, Antennas

DESIGN OF A CLASSIFIED COMMUNICATIONS SATELLITE SYSTEM

Herschel H. Loomis, Jr., Professor

Department of Electrical and Computer Engineering and Space Systems Academic Group

Sponsor: Hughes Space and Communications

OBJECTIVE: To provide technical support to a design effort for a government communications satellite system.

SUMMARY: Provided technical support to the design of the communications waveform design and concept of operations of a classified communications satellite system for the U. S. government.

DoD KEY TECHNOLOGY AREAS: Other (Information Superiority)

KEYWORDS: Communications Satellite, Communications Waveform Design

NSA/C4 COMPUTER NETWORK RESEARCH LABORATORY AND THESIS RESEARCH

Herschel H. Loomis, Jr., Professor

Department of Electrical and Computer Engineering and Space Systems Academic Group

CAPT James Powell, USN

Department of Information Science

Sponsor: National Security Agency

OBJECTIVE: This effort will continue and expand and enhance the capabilities and research focus of the computer network research laboratory.

PROJECT SUMMARIES

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Network, Security, Computer, Software, Information Operations

NAVAL SIMULATION SYSTEMS CRYPTOLOGIC STUDIES

Hershel H. Loomis, Jr., Professor

Department of Electrical and Computer Engineering and Space Systems Academic Group

Sponsor: Space and Naval Warfare Systems Center - San Diego

OBJECTIVE: NPS will provide a tailored technical update to the 04/05 mid-career CNSG course to meet schedule and educational requirements.

SUMMARY: The course was taught at CNSG headquarters (HQ) from 5-9 February 2001. The course will cover technical aspects of signals intelligence (SIGINT) to include an understanding of SIGINT concepts, information assurance and information operations. The course addressed difficult technical concepts as themes. Each theme provides the cryptologist the essence of the area of study. Three basic themes were selected to focus and organize the topics of instruction.

DoD KEY TECHNOLOGY AREAS: Other (Information Superiority)

KEYWORDS: Signals Intelligence

PROJECT GUSTY ORIOLE

Hershel H. Loomis, Jr., Professor

Department of Electrical and Computer Engineering and Space Systems Academic Group

RADM Thomas C. Betterton, USN (Ret), Naval Space Technology Chair

Alan Ross, Navy Tactical Exploration of National Capabilities (TENCAP) Chair Professor

Space Systems Academic Group

Sponsor: Secretary of the Air Force

OBJECTIVE: To conduct research into architectures and algorithms for the acquisition, processing, and communication of tactical information. To provide support for the course Space Systems 3001, Military Applications of Space and SS4051, Military Space Systems and Technologies.

SUMMARY: Completed work on the following tasks: a) Developed plans for a Satellite Communications System, which has been funded through Boeing Space Systems. b) Triple-modular-redundancy computer designs completed for 64-bit microprocessor and for DSP COTS ASIC. Continued service on Ph.D. committee for NRL code 8000 employee on modeling of behavior of microprocessors in Single Event Effect environment. c) Began book *Emitter Geolocation* in collaboration with Dr. Michael Price. d) Supported Courses SS 3001 & SS4051 by the development of geolocation material and the arrangement of field trips to visit contractor sites. e) Attended meetings of government LPI Communications Committee; hosted 2-day meeting of committee at NPS in January 2001.

PUBLICATIONS:

Miller, J.B., McEachen, J.C., Loomis, H.H., Tope, M.A. and Copeland, D.B., "An Analysis of Noise in Timing-based Communications over LANs," accepted by ISCAS 2002, the IEEE International Symposium on Circuits and Systems.

Loomis, H.H., *Geolocation of Electromagnetic Emitters*, Naval Postgraduate School Technical Report, NPS-EC-00-003, January 2001 (revised edition).

PROJECT SUMMARIES

THESES DIRECTED:

Ecken, H.B., "Feasibility Analysis and Design of a Fault Tolerant Computing System: A TMR Microprocessor System Design of 64-Bit COTS Microprocessors," Masters Thesis, Naval Postgraduate School, March 2001.

Wukich, M.J., "Using Commercial Off The Shelf (COTS) Digital Signal Processors (DSP) for Reliable Space Based Digital Signal Processing," Masters Thesis, Naval Postgraduate School, March 2001.

Johnson, J.J., "Implementing the Cross Ambiguity Function and Generating Geometry-Specific Signals," Masters Thesis, Naval Postgraduate School, September 2001.

Dorcey, C.T., "FFT-Based Spectrum Analysis Using a Digital Signal Processor," Masters Thesis, Naval Postgraduate School, September 2001.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Sensors

KEYWORDS: Space-based Reconnaissance, Signals Intelligence

SECURITY VULNERABILITIES OF WIRELESS PROTOCOLS

John McEachen, Assistant Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Engineering Logistics Office

OBJECTIVE: Perform research into the internal protocols of wireless computer networks and identify vulnerabilities associated with their standard implementation. Examine use of cellular-based protocols such as Mobitex and CDPD for data communications. Begin investigation into the interface of wireless networks with landline IP networks in the interest of examining upcoming technologies such as WAP and IP telephony.

SUMMARY: Interest in portable, high-bandwidth digital communications methods spans the world and presents a formidable challenge to the Defense Department of the United States. While anxious to use new communications equipment, the armed services are wary of the vulnerabilities they expose. This project examines the vulnerability of wireless local area networks (WLANs) when used by tactical units in an urban setting. Initial efforts on this project consisted of the development of a baseline IEEE 802.11a computer simulation using OPNET. These models have been highly praised and are already in use by organizations such as Philips Electronics and BDM. More recent efforts have focused on the stand-off detection ranges of WLANs. This project also has identified several denial of service issues in the IEEE 802.11 control and management functions.

PUBLICATIONS:

McEachen, J.C. and Cay, A., "Queue Response of Correlated Traffic Insertion in ATM Networks," *IEEE Transactions in Networking*, in review.

McEachen, J.C. and Cay, A., "Connection Utilization Masking in ATM Networks," *International Journal on Information Security*, in review.

Tope, M.A. and McEachen, J.C., "Unconditionally Secure Communications over Fading Channels," *Proceedings of the 2001 IEEE Military Communications International Symposium (MILCOM 2001)*, Washington, D.C., October 2001.

Mullin, S.C. and McEachen, J.C., "Vulnerabilities in Multiprotocol Label Switching Label Distribution," *Proceedings of the 2001 IEEE Military Communications International Symposium (MILCOM 2001)*, Washington, D.C., October 2001 (classified publication).

PROJECT SUMMARIES

Braswell, B.E. and McEachen, J.C., "Modeling Data Rate Agility in the IEEE 802.11a WLAN Protocol," *Proceedings of OPNETWORK2001*, Washington, D.C., August 2001.

Braswell, B.E., McEachen, J.C. and Batson, M.S., "A Baseline Model for IEEE 802.11a WLAN Protocol," *Proceedings of OPNETWORK2001*, Washington, D.C., August 2001.

McEachen, J.C. and Cay, A., "Masking Compressed Video Connection Utilization in ATM Networks," *Proceedings of the 2001 IEEE International Symposium on Circuits and Systems (ISCAS 2001)*, Vol. V, Sydney, Australia, pp. 145-148, May 2001.

McEachen, J.C., Ow, K.C. and Lim C.T., "A System Level Description and Model of Signaling System No. 7," *Proceedings of the 2001 IEEE International Symposium on Circuits and Systems (ISCAS 2001)*, Vol. IV, Sydney, Australia, pp. 258-261, May 2001.

McEachen, J.C., *Route Intervention in Packet Networks*, Naval Postgraduate School Technical Report, NPS-EC-01-009, May 2001 (Classified Top Secret/SCI).

McEachen, J.C. and Braswell, B., *Vulnerabilities in Control and Management Functions of IEEE 802.11 Wireless LANs*, Naval Postgraduate School Technical Report, NPS-EC-01-001, February 2001.

PRESENTATIONS:

McEachen, J.C., "Computer Networking in the Department of Defense," lecture to Introductory Engineering Class, Santa Clara University, 8 November 2001.

McEachen, J.C., "Teaching with OPNET," OPNETWORK2001, Washington, D.C., 30 August 2001.

THESES DIRECTED:

Mallory, P.L., "Extending IEEE 802.11b Wireless Local Area Networks to the Metropolitan Area," Masters Thesis, Naval Postgraduate School, December 2001.

Geissler, W.K., "Exploitation of Transmission Control Protocol Error Handling as a Means of Covert Communications," Masters Thesis, Naval Postgraduate School, September 2001.

Maloy, R.C., "Performance Metrics for an ATM Network Using Local Area Network Emulation (LANE) and Switched Ethernet," Masters Thesis, Naval Postgraduate School, September 2001.

Kinney, A.C., "Analysis of M-JPEG Video over an ATM Network," Masters Thesis, Naval Postgraduate School, June 2001.

Braswell, B.E., "Modeling Data Rate Agility in the IEEE 802.11a Wireless Local Area Networking Protocol," Masters Thesis, Naval Postgraduate School, March 2001.

Mullin, S.C., "Vulnerabilities of Multiprotocol Label Switching," Masters Thesis, Naval Postgraduate School, March 2001.

Tan, K.C., "Development and Simulation of the IEEE 802.11a Physical Layer in a Multipath Environment," Masters Thesis, Naval Postgraduate School, March 2001.

Chua, G.H., "An Architecture for Analysis and Collection of RF Signals Used by Hand-held Devices in Computer Communications," Masters Thesis, Naval Postgraduate School, March 2001.

Lam, W., "Meeting SIGINT Constraints in IP Telephony," Masters Thesis, Naval Postgraduate School, March 2001.

PROJECT SUMMARIES

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Modeling and Simulation, Computing and Software

KEYWORDS: 802.11, ATM, Wireless, LAN, High Speed Networking, Ad-Hoc Networking

THERMODYNAMIC MODELING FOR INTRUSION DETECTION

John McEachen, Assistant Professor
Department of Electrical and Computer Engineering
James Luscombe, Professor
Department of Physics
Chris Frenzen, Associate Professor
Department of Applied Mathematics
Sponsor: Defense Information Systems Agency

OBJECTIVE: Develop alternative methods for intrusion detection in computer networks. Specifically, examine the use of statistical mechanics in modeling the dynamics of network conversations.

SUMMARY: This interdisciplinary project explored the use of thermodynamic principles to model the flux of conversations across a network boundary. The major deliverable of this project was the Terminator 2 software program developed and installed at the U.S. Pacific Command. A revised version of the software was also installed at the U.S. Army Signal Command, Ft. Huachuca, AZ.

PUBLICATIONS:

McEachen, J.C., Donald, S.D., McMillen, R.V. and Ford, D.K., "Using Thermodynamics to Model Network Conversation Dynamics for Intrusion Detection," *IEEE Transactions in Networking*, in review.

McEachen, J.C., Donald, S.D., McMillen, R.V. and Ford, D.K., "A Thermodynamics-based Model of Network Conversation Flux for Intrusion Detection," to appear in *Proceedings of the IIIS 6th World Multi Conference on Systemics, Cybernetics and Informatics (SCI 2002)*, Orlando, FL, July 2002.

McEachen, J.C., Donald, S.D., McMillen, R.V. and Ford, D.K., "Terminator 2: A Thermodynamics-based Method for Patternless Intrusion Detection," to appear in *Proceedings of the 2002 IEEE Military Communications International Symposium (MILCOM 2000)*, Los Angeles, CA, October 2002.

PRESENTATIONS:

McEachen, J.C., "Terminator 2: A Real Time Thermodynamic-Based Patternless Intrusion Detection System," AFWIC Phoenix Challenge 2002, Las Cruces, NM, 20 February 2002.

THESES DIRECTED:

Donald, S.D. and McMillen, R.V., "Terminator 2: Developing a Real Time Thermodynamic Based Patternless Intrusion Detection System," Masters Thesis, Naval Postgraduate School, September 2001.

Sharlun, G.F., "Defining and Validating a Covert Analysis Detection (CAD) System and its Stealthy Data Capture, Control and Analysis Capabilities," Masters Thesis, Naval Postgraduate School, June 2001.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Modeling and Simulation, Computing and Software

KEYWORDS: Intrusion Detection, Thermodynamics, Statistical Mechanics, High Speed Networking

PROJECT SUMMARIES

TIMING CHANNELS IN PACKET NETWORKS

John McEachen, Assistant Professor

Department of Electrical and Computer Engineering

Sponsor: National Security Agency

OBJECTIVE: Examine the use of packet timing as an alternative communications mechanism. Characterize delay in a variety of network environments.

SUMMARY: This project is based on the work of B. Verdu (1998) in communicating information using inter-packet delay in data networks. This work is largely classified. Work on this project began in February 2002.

PUBLICATIONS:

Miller, B., Copeland, D., Tope, M., Loomis, H. and McEachen, J.C., "An Analysis of Noise in Timing-based Communications over LANs," to appear in *2002 IEEE International Symposium on Circuits and Systems*, Phoenix, AZ, May 2002.

DoD KEY TECHNOLOGY AREA: Command, Control and Communications

KEYWORDS: Packet Networks, Information Theory, Steganography

RADIATION TOLERANT ASIC AND PHOTOVOLTAIC DEVICES FOR SPACE BASED SYSTEMS

Sherif Michael, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: National Reconnaissance Office

OBJECTIVE: To design radiation tolerant mixed mode VLSI and ASIC circuits for space applications. To fabricate these design after extensive simulation using regular silicon process as a first step. To study the Space radiation effects on these state-of-the-art designs using the NPS LINAC as a radiation source. Upon verification of the experimental results, the layout will be submitted for future fabrication using SOI process.

SUMMARY: Continuation of the ongoing research on radiation effects and the design of radiation hardened electronic devices for space applications. The design and fabrication of a high performance digitally programmable VLSI circuit for space-based system. The design is based on a technique that was developed earlier by the investigator, and has shown excellent sensitivity performance. The mixed mode signal circuit, using BiCMOS Techniques is currently under development. Previously fabricated VLSI ASIC chips will also be irradiated using the NPS LINAC for testing its performance under radiation environment. Past experimental results using this technique has shown great improvements in the circuits radiation performance.

PUBLICATIONS:

Michael, S. and Pieper, R., "A VLSI Implementation of a Universal Programmable Low Sensitivity Sampled Data Filter," *IEEE International Symposium on Circuits and Systems*, Vol. 4, pp. 674-677. Sydney, Australia, 6-9 May 2001.

Pieper, R. and Michael, S., "Application of a Robust Algorithm for Predicting Freeze-out and Exhaustion Under a Variety of Nontrivial Conditions," *IEEE International Symposium on Circuits and Systems*, Vol. 2, pp. 477-480, Sydney, Australia, 6-9 May 2001.

PROJECT SUMMARIES

THESES DIRECTED:

Fifer, T., "Radiation Effects on Multi-Junction Solar Cells," Masters Thesis, Naval Postgraduate School, December 2001.

Milne, P.R., "The Design, Simulation, and Fabrication of a BiCMOS VLSI Digitally Programmable Filter," Masters Thesis, Naval Postgraduate School, September 2001.

DoD KEY TECHNOLOGY AREAS: Electronics, Environmental Effects, Other (Space Applications)

KEYWORDS: Space Radiation Effects, Satellites, Annealing, Radiation Hardened, Computer Modeling

GUSTY YEARLING, TASK A

Michael A. Morgan, Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Engineering Logistics Office

OBJECTIVE: This is a TS level compartmented Special Access Project. No accurate description can be provided for publication in this forum.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Antennas, Propagation, Impulse Radiation

MAGNETIC FIELD SENSOR PLACEMENT AND TIME-REVERSED EM IMAGING STUDIES

Michael A. Morgan, Professor

Department of Electrical and Computer Engineering

Sponsor: Office of Naval Research

OBJECTIVES: This project included two independent investigations, each of which formed the topic of an M.S. Thesis. The first topic sought to optimize near-surface sensor placements to increase the prediction accuracy of magnetostatic near-fields surrounding ferromagnetic objects. Time-reversed wave equation solutions in acoustics were extended to electromagnetics in the second topic, with application to radar imaging.

SUMMARY: Progress for the first topic included: (1) development of a modal algorithm for the field solution due to an axial array of dipoles enclosed within a ferromagnetic spheroidal shell; (2) testing with additive noise of an SVD based least-squares field prediction algorithm using point sensor data, and; (3) extensive searches for optimal sensor placement configurations and the cataloging of findings. Progress for the second topic included development of a finite-difference time-domain simulation and evaluation of imaging accuracy for various levels of noise and sparsity of boundary data.

PRESENTATIONS:

Morgan, M.A. and Steenman, D.G., LT, USN, "Null Spaces for Near-Field Imaging," 2001 URSI National Radio Science Meeting, Boston, MA, 10 July 2001.

Morgan, M.A., Yopp, S.W., LT, USN and Kildishev, A.V., "Optimal Sensor Placement for Magnetic Signature Prediction," 2001 Intermag Symposium, Amsterdam, Netherlands, 2 May 2001.

Kildishev, A.V., Nyenhuis, J.A. and Morgan, M.A., "Multipole Analysis of an Elongated Magnetic Source by a Cylindrical Sensor Array," 2001 InterMag Symposium, Amsterdam, Netherlands, 2 May 2001.

PROJECT SUMMARIES

THESES DIRECTED:

Yopp, S.W., "Magnetic Field Estimation Using Optimal Locations of Near Field Sensors," Masters Thesis, Naval Postgraduate School, June 2001.

Inaba, Y., "Radar Target Imaging Using Time-Reversed Processing," Masters Thesis, Naval Postgraduate School, September 2001.

DoD KEY TECHNOLOGY AREAS: Sensors, Modeling and Simulation

KEYWORDS: Optimal Sensor Placement, Magnetostatic Field Prediction, Time-Reversed Electromagnetics, Radar Imaging

OPTIMIZED WIDEBAND LOW-PROFILE COMMUNICATION ANTENNA DESIGN

Michael A. Morgan, Professor

Department of Electrical and Computer Engineering

Sponsor: U.S. Army Research Office

OBJECTIVE: Optimal designs of wideband omnidirectional VHF communication antennas will be investigated for rotary-wing and armored vehicle applications.

SUMMARY: Optimization will involve tradeoffs of antenna performance and efficiency constrained by required bandwidth and use of blister type profiles for low aerodynamic drag and minimal surface protrusion. Design will use metallic surface contouring and inhomogeneous dielectric loading under size and shape constraints.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Wideband, Finite Elements, Antenna Design

MODELING AND SIMULATION OF IMPULSIVE RADIATION AND PROPAGATION

Michael A. Morgan, Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Surface Warfare Center

OBJECTIVE: The goal of this task is to investigate the impulse radiation characteristics of specified antennas in the presence of buildings over real earth

SUMMARY: Wire-grid numerical modeling of antenna and building structures has been completed using frequency-stepped calculations using the Numerical Electromagnetics Code (NEC-4). Impulsive near-fields within the modeled building are found using time-domain source modeling and inverse FFT convolution. Animations of fields within the structure are created using custom MatLab programs.

PRESENTATION:

Morgan, M.A., "Impulsive Field Computation and Measurement," 2001 URSI National Radio Science Meeting, Boston, MA, July 10, 2001.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Impulse Response, Antenna Modeling, Near-Fields, NEC

PROJECT SUMMARIES

DETERMINING AN OPTIMUM SENSOR NETWORK CONFIGURATION

Phillip E. Pace, Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Air Systems Command

OBJECTIVE: This proposal investigates using the Advanced Reactive Electronic Warfare Simulation (ARES) to determine optimum sensor network configurations for applications in electronic attack (EA) and suppression of enemy air defense (SEAD).

SUMMARY: As a first step, appropriate measures of effectiveness (MOEs) were developed in order to define the fitness of a sensor network. For example, a "perfect" sensor network would know everything about the environment with 100% accuracy instantaneously. Appropriate MOEs, therefore, would optimize the sensor network (radars and ESMs) toward perfection (e.g., minimize latency, maximize information content). Working closely with Code 5700 the developed MOEs were embedded into the ARES. The various MOEs were tested to quantify the sensitivity of the solution to (a) the choice of MOE, and (b) the application. From this it was determined if there was an overall best MOE for optimizing the sensor network. The optimized sensor network was applied to several engagement problems (EA and several types of SEAD) in order to determine how well network supported the application.

THESIS DIRECTED:

Pham, P.N., "Sensitivity Analysis of an Optimum Multi-Component Airborne Electronic Attack Configuration for Suppression of Enemy Air Defense," Masters Thesis, Naval Postgraduate School, March 2001.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare, Sensors, Electronics, Modeling and Simulation

KEYWORDS: Electronic Attack, Network-Centric Warfare, Optimum Sensor Configuration, Measures of Effectiveness

DIGITAL TARGET IMAGING ARCHITECTURES

Phillip E. Pace, Professor

Douglas J. Fouts, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Office of Naval Research

OBJECTIVE: The technical objective of this research is twofold. The first objective is to quantify the system-level implementation tradeoffs of a digital, programmable imaging architecture to generate realistic false target signatures against high resolution imaging radars, including synthetic aperture radar (SAR) and inverse SAR (ISAR), using all-digital techniques and modern digital radio frequency memory (DRFM) technology. The second objective is to design, fabricate and test an all-digital target imaging device capable of generating large false targets using wideband chirp signals of any duration to provide a new, superior, radio frequency (RF) decoy capability.

SUMMARY: A sequence of simulations was completed to quantify various different design tradeoffs in the high-level architecture of the digital image synthesizer (DIS). The simulations were started during the previous year's effort of this 3-year project. Based on the simulation results, a new, high-performance architecture was developed for the DIS. The design of a high-speed CMOS application-specific integrated circuit (ASIC) that implements the new architecture was then started. The design of this ASIC is now more than half completed, including schematic capture, circuit simulation, mask layout, design rule checking, layout verification, and logic simulation. Simulations indicate the ASIC will function correctly at clock speeds of up to 780 MHz, well beyond the 600 MHz target frequency of the baseband signal. An interface circuit is also being developed to interface the ASIC with a new type of DRFM being developed at the Naval Research Laboratory.

PROJECT SUMMARIES

PUBLICATIONS:

Fouts, D.J., Pace, P.E., Karow, C. and Ekestorm, S., "A Single Chip False Target Radar Image Generator for Countering Wideband Imaging Radars," *IEEE Journal of Solid State Circuits* (accepted for publication).

Pace, P.E., Fouts, D.J., Ekestorm, S. and Karow, C., "Digital False Target Image Synthesizer for Countering ISAR," *IEE Proceedings Radar, Sonar and Navigation* (in review).

PRESENTATIONS:

Pace, P.E. and Fouts, D.J., "Digital Target Imaging Architecture for Multiple Large-Target Generation," Office of Naval Research Electronic Warfare Science and Technology Gatherings, Washington, D.C., 9 May 2001.

Pace, P.E., Fouts, D.J., Amundson, C.A. and Guillaume, C., "Digital Target Imaging Architecture for Multiple Large-Target Generation: Critical Design Review," Naval Research Laboratory, Washington, D.C., 6 September 2001.

Fouts, D.J. and Pace, P.E., "Digital Target Imaging Architecture for Multiple Large-Target Generation: Progress Report," Office of Naval Research, Washington, D.C., 19 December 2001.

THESES DIRECTED:

Kirin, K.M., "VLSI Design of Sin/Cos Lookup Table for Use With Digital Image Synthesizer ASIC," Masters Thesis, Naval Postgraduate School, June 2001.

Amundson, C.A., "Design, Implementation, and Testing of a High Performance Summation Adder for Radar Image Synthesis," Masters Thesis, Naval Postgraduate School, September 2001.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare, Sensors, Electronics, Computing and Software

KEYWORDS: Imaging Decoys, Inverse Synthetic Aperture Radar, Counter-Targeting, Counter-Terminal, Digital Radio Frequency Memories, DRFM

NAVY SURFACE ANTI-SHIP CRUISE MISSILE THREAT SIMULATOR VALIDATION WORKING GROUP

Phillip E. Pace, Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Research Laboratory

OBJECTIVE: The objective of this proposal is to provide technical leadership to the Navy Surface Anti-Ship Cruise Missile Threat Simulator Validation Working Group. Three types of simulations are currently being validated by the SVWG for use in test and evaluation. These include (a) radio frequency missile hardware simulators, (b) infrared missile hardware simulators and (c) computer models of missile seekers and related electronics.

SUMMARY: The duties for the SVWG chairman include coordinating with the Navy's Simulator Validation Coordinator, the NRL ENEWS Program Manager and other Navy commands (e.g., Commander Operational Test and Evaluation Force) to prioritize the simulator validations for N912 approval. Additional responsibilities include coordinating with the Office of Naval Intelligence for threat data review and convening the SVWG as an independent and unbiased reviewer for all of the validation reports.

PROJECT SUMMARIES

PUBLICATIONS:

Pace, P.E., Zulaica, D., Nash, M.D., DiMattesa, A.D. and Hosmer, A.C., "Relative Targeting Architectures for Captive-Carry HIL Missile Simulator Experiments," *IEEE Transactions on Aerospace and Electronic Systems*, Vol. 37, No. 3, pp. 810-823, July 2001.

Pace, P.E., "Adaptive Power-Managed FMCW Emitter Detection Performance Against Low-RCS Ships," *Proceedings of the IEEE 35th Asilomar Conference on Signals, Systems and Computers*, MP8b, Monterey, CA, 2 November 2001.

PRESENTATION:

Pace, P.E., "Infrared Systems and Analysis," N9 Threat ASCM Simulator Validation Working Group, Naval Research Laboratory, 26 June 2001.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare, Sensors, Electronics, Computing and Software

KEYWORDS: Anti-Ship Cruise Missiles, Simulators, Captive-Carry, Hardware-in-the-Loop

OPTIMUM SENSOR NETWORK CONFIGURATION FOR SEAD

Phillip E. Pace, Professor

Department of Electrical and Computer Engineering

Sponsor: Johns Hopkins University, Applied Physics Laboratory

OBJECTIVE: This proposal continues the investigation using the Advanced Reactive Electronic Warfare Simulation (ARES) to determine optimum sensor network configurations for applications in electronic attack (EA) and suppression of enemy air defense (SEAD).

SUMMARY: A sensitivity analysis of the solution evolved by simulation was performed in order to determine the robustness in the derived measures of effectiveness to system failures or variances in the performance parameters. The tasks involved with this effort included simulating the RT-4 distributed scenarios to baseline the corresponding measure of effectiveness (i.e., target engagement time by surface-to-air missile site). One or more parameters in the scenario solution were then changed (receiver dynamic range, jamming assignment, etc.) and the measures of effectiveness were re-derived in order to investigate their sensitivity to these changes. In addition, this project developed a User's Guide for the Naval Research Laboratory (NRL) Advanced Reactive Electronic Warfare Simulation (ARES) software Version 1.12 used in the analysis.

PUBLICATION:

Pace, P.E., Wickersham, D., Jenn, D. and York, N., "High Resolution Phase Sampled Interferometry Using Symmetrical Number Systems," *IEEE Transactions on Antennas and Propagation*, Vol. 49, No. 10, pp. 1411-1423, October 2001.

THESIS DIRECTED:

Pham, P.N., "Sensitivity Analysis of an Optimum Multi-Component Airborne Electronic Attack Configuration for Suppression of Enemy Air Defense," Masters Thesis, Naval Postgraduate School, March 2001. (Classified Secret)

DoD KEY TECHNOLOGY AREAS: Electronic Warfare, Sensors, Electronics, Modeling and Simulation

KEYWORDS: Electronic Attack, Network-Centric Warfare, Optimum Sensor Configuration, Measures of Effectiveness

PROJECT SUMMARIES

PHOTONIC ADC ARCHITECTURES FOR MICROWAVE SIGNAL COLLECTION AND ANALYSIS

Phillip E. Pace, Professor

John P. Powers, Distinguished Professor

Department of Electrical and Computer Engineering

Sponsor: Defense Advanced Research Projects Agency

OBJECTIVE: The objective of this proposal is the experimental investigation of a photonic architecture for high-speed sampling and digitalization of RF and microwave signals.

SUMMARY: The proposed effort consists of three options for funding level (per sponsor request). The photonic ADC used a mode-locked laser to oversample an input signal at two mach-zehnder interferometers. A fiber lattice accumulator is embedded within a feedback loop around a single-bit quantizer to spectrally shape the quantization noise to fall outside the signal band of interest. Decimation filtering is applied to the quantizer output to construct the input signal with high resolution. It was proposed to investigate the following: The effects of non-uniform sampling (JITTER), the accumulator leakage resulting from a mismatch in optical circuit parameters, the spurious free dynamic range, signal-to-noise plus distortion ratio AND effective number of bits for several oversampling ratios.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Sensors, Sampling, Electro-Optic, Photonics

REVOLUTION IN BATTLESPACE TECHNOLOGIES WORKSHOP 2001

Phillip E. Pace, Professor

Department of Electrical and Computer Engineering

Sponsor: Swedish National Defense College

OBJECTIVE: This 3-week course hosted by the NPS Center for Joint Services Electronic Warfare, is intended for international military officers and technical research personnel who are interested in the technologies of command and control warfare (C2W).

SUMMARY: The course was sponsored by the Swedish National Defence College (SNDC), and ordered through the Security Assistance Office at the American Embassy in Stockholm under MASL P179220. This year, the workshop was held from April 23 through May 11, 2001. A total of 31 NDC students and eight supporting SNDC staff (including Brigadier General Bjorn Andersson) attended the workshop. All course materials and textbooks were supplied to the students. During the first week there was an Opening Reception and a photo taken of all participants in the course. A field trip to Condor Systems was also taken during the second week. A Flag Dinner and Graduation Ceremony and Dinner were held in week three. Upon completion of the course, students received a Certificate of Graduation. All course materials were mailed back to SNDC upon completion of the course.

PUBLICATION:

Pace, P.C., "Advanced Technical Workshop 2001: Revolutions in Battlespace Technology," Center for Joint Services Electronic Warfare, Volumes I-IV, 23 April-11 May 2001.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare, Sensors, Electronics, Modeling and Simulation

KEYWORDS: Workshop, Short Courses, Technology, NPS Center For Joint Services Electronic Warfare

PROJECT SUMMARIES

ELECTRONIC WARFARE ADVANCED TECHNOLOGY STUDIES

R. Clark Robertson, Professor

Ron Pieper, Visiting Associate Professor

Department of Electrical and Computer Engineering

Sponsors: Naval Air Warfare Center

OBJECTIVE: The objective of this project was to determine IRCM effectiveness for the F/A-18-E/F for both a smart and a dumb SA threat and a smart AA threat with both straight and level flight as well as maneuvering. In addition, the results obtained with an area source model were to be compared to those obtained with the SPIRITS model.

SUMMARY: The objective of this study was to evaluate MOSAIC based counter-measure predictions for the F/A-18-E/F platform. Various questions were addressed, such as:

1. Do maneuvers when combined with flare drops produce an overall countermeasure improvement for the F/A-18-E/F?
2. Do changes in atmospheric conditions and platform altitude tend to enhance or diminish countermeasure effectiveness?
3. Do the "area" source miss distance results differ significantly with predictions generated using the SPIRITS model? Also, can the percentage of cases in which models disagree as to whether the simulation ends in hit or miss be established?

These questions were addressed for an experimental matrix using various flare salvos, aircraft altitudes, aircraft speeds, and missile types, both surface-to-air and air-to-air. This project is ongoing and will conclude in March 2002.

PRESENTATION:

Robertson, C., "IRCM Effectiveness for the F/A-18-E/F," PMA-272, Patuxent River, MD, October 2001.

THESIS DIRECTED:

Lott, B., "IRCM Effectiveness for the F/A-18-E/F," Masters Thesis, Naval Postgraduate School, March 2002.

DoD KEY TECHNOLOGY: Electronic Warfare

KEYWORDS: Electronic Countermeasures, IR Countermeasures, IR Sensors

BEARTRAP POST-MISSION ANALYSIS SYSTEM

Murali Tummala, Professor

Charles W. Therrien, Professor

Department of Electrical and Computer Engineering

Sponsor: Advanced Maritime Program Office, Naval Air Station - Patuxent River

OBJECTIVE: To design and develop a signal processing system capable of implementing narrowband frequency tracking, multi-target tracking, wideband and related processing, time-domain analysis, and data fusion for Beartrap post-mission analysis or S2K (for System 2000).

SUMMARY: During 2001, the project was not funded and the activity has been phased out and transferred to the Beartrap site at Brunswick, Maine. The beta testing of the software delivered during 2000 is being carried out at designated sites. The principal investigators are no longer involved in the project.

DoD KEY TECHNOLOGY AREAS: Sensors, Computing and Software, Human Systems Interface, Other (Signal Processing)

KEYWORDS: Signal Processor Design, Acoustic Signal Processing, Graphical User Interface Design

PROJECT SUMMARIES

JSIPS-N COMMUNICATIONS ARCHITECTURE MODELING AND SIMULATION

Murali Tummala, Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Aviation Depot - Cherry Point

OBJECTIVE: To develop a simulation model for JSIPS-N packet switched communications network, including local and wide area segments and other network components. Issues to be addressed in this effort are performance indicators, assessment of alternate network topologies and system constraints in terms of capacity limitations and maximum number of sites supportable.

SUMMARY: This work produced a baseline model of the Joint Services Image Processing System – Navy Communications system. The model was designed with future expansion in mind, thus it can be used as a design tool and as a means to simulate operational performance prior to making actual design modifications on the network. It can also serve as a management tool to identify areas that require improvement or upgrades. The results illustrate how the baseline model can be used to simulate various operating scenarios. The model was successful in evaluating the overall performance of the system and provided significant data on areas that may require upgrading or configuration improvement.

THESIS DIRECTED:

Hootman, J., "JSIPS-N Baseline Architecture Simulation and Performance Evaluation," Masters Thesis, Naval Postgraduate School, in progress.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications

KEYWORDS: Ad Hoc Wireless Networks, Software Defined Radio, Joint Tactical Radio System, Digital Modular Radio

JOINT TACTICAL RADIO SYSTEM (JTRS) AND DIGITAL MODULAR RADIO

Murali Tummala, Professor

Department of Electrical and Computer Engineering

Sponsor: Space and Naval Warfare Systems Center - San Diego

OBJECTIVE: To develop graduate level course materials for wireless networks with emphasis on software defined radio principles and in support of the digital modular radio program. As part of the work, also investigate the mobile ad hoc routing protocols for use in the DMR program.

SUMMARY: The effort to develop materials for a course on wireless networks and software-defined radio continued during 2001. The routing protocols have been investigated for mobile ad hoc networks: distributed source routing. The effects of the data link, network, and transport level protocols on the quality of real-time data have been studied.

THESIS DIRECTED:

da Silva Mattos, L., "Quality-of-Service Schemes for Mobile Ad-Hoc Networks," Masters Thesis, Naval Postgraduate School, March 2001.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Computing and Software

KEYWORDS: Ad Hoc Wireless Networks, Software Defined Radio, Joint Tactical Radio System, Digital Modular Radio

PROJECT SUMMARIES

QUALITY-OF-SERVICE IN MOBILE AD HOC NETWORKS

Murali Tummala, Professor

Department of Electrical and Computer Engineering

Sponsor: Space and Naval Warfare Systems Center - San Diego

OBJECTIVE: Develop algorithms for quality-of-support assurance in mobile ad hoc networks. Traffic conditioning, marking, and buffer management have been investigated to provide quality of service assurance for real-time traffic in JTRS like environments.

SUMMARY: To achieve QoS, independently of the routing protocol, each mobile node participating in the network must implement traffic conditioning, traffic marking and buffer management or queue scheduling schemes. In MANETs, since the mobile nodes can have simultaneous multiple roles, it was found that traffic conditioning and marking must be implemented in all mobile nodes acting as source nodes. Buffer management and queue scheduling schemes must be performed by all mobile nodes. QoS schemes for different types of traffic, geographical areas of different sizes and various mobility levels have been simulated and their performance studied. Metrics, such as throughput, end-to-end delay and packet loss rates, were used to measure the relative improvements of QoS-enabled traffic sessions. The results indicate that in the presence of congestion, service differentiation can be achieved under different scenarios and for different types of traffic whenever a physical connection between two nodes is realizable.

THESIS DIRECTED:

da Silva Mattos, L., "Quality-of-Service Schemes for Mobile Ad-Hoc Networks," Masters Thesis, Naval Postgraduate School, March 2001.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications

KEYWORDS: Ad Hoc Wireless Networks, Software Defined Radio, Joint Tactical Radio System, Digital Modular Radio

RF DISTRIBUTION SYSTEMS AND DMR INTEROPERABILITY

Murali Tummala, Professor

Department of Electrical and Computer Engineering

Sponsor: Space and Naval Warfare Systems Center - San Diego

OBJECTIVE: To provide research and development support for the digital modular radio procurement program. Issues to be addressed in this effort are integration of distribution systems and interoperability with the digital modular radio system.

SUMMARY: The work consisted of two phases: conducting research to investigate algorithms to provide better traffic management in DMR like environments and interacting with the sponsor and participating in planning and review meetings to assess the interoperability and system procurement. Active queue management mechanisms for real-time traffic for DMR like environments have been developed. A new algorithm called selective early discard (SED) that selectively drops packets in order to spread the packet losses in a queue has been proposed. Using simulation, the new schemes are evaluated in a MANET environment, and their performance is compared with other existing QoS schemes. Results indicate that SED minimizes the burst errors due to buffer overflow, thereby improving the performance for real-time traffic. SED is also capable of providing service differentiation; additional performance improvement can be realized by utilizing timestamps.

THESIS DIRECTED:

Fountanas, L., "Active Queue Management Mechanisms for Real-Time Traffic in MANETs," Masters Thesis, Naval Postgraduate School, December 2001.

PROJECT SUMMARIES

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications

KEYWORDS: Ad Hoc Wireless Networks, Software Defined Radio, Joint Tactical Radio System, Digital Modular Radio

SIGNAL-TO-NOISE ENHANCEMENT PROGRAM

Wilbur R. Vincent, Associate Research Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Security Group

OBJECTIVE: To define factors that adversely affect signal reception at receiving sites, determine the primary characteristics of factors, identify all factors, and provide recommendations for effective mitigation actions.

SUMMARY: Radio noise from overhead power lines has been identified as the major factor limiting the reception of radio signals at 36 of 37 sites examined. This little recognized factor is seriously limiting the effectiveness of HF, VHF, and UHF intercept systems to collect signals of special interest. The primary properties of this noise have been defined, source location procedures have been devised, and a means to identify source hardware has been generated. This effort has generated a number of technical papers and presentations during the last year. Some related work on signal reception in the microwave ISM bands has also been conducted.

PUBLICATIONS:

Parker, A.A., Adler, R.W. and Vincent, W.R., *Conducted EMI from an Engineering Model of DC-to-DC Converter*, Naval Postgraduate School Technical Report, NPS-EC-01-007, June 2001.

Melnick, C., Munsch, G. and Vincent, W., "Signal Reception Survey and Site LZO," prepared for National Security Agency with assistance from Argon Engineering Associates.

PRESENTATIONS:

Vincent, W., Adler, R. and Munsch, G., "A Review of Man-Made Radio Noise at 37 HF Receiving Sites," Conference on Factors Affecting the Reception of Radio Signals, Naval Postgraduate School, 5-6 March 2001.

Vincent, W.; Munsch, G. and Adler, R., "A Progress Report on a Model for Man-Made Noise at HF Receiving Sites," Conference on Factors Affecting the Reception of Radio Signals, Naval Postgraduate School, 5-6 March 2001.

Parker, A., Adler, R. and Vincent, W., "Spectrum Signatures of Man-Made Noise," Conference on Factors Affecting the Reception of Radio Signals, Naval Postgraduate School, 5-6 March 2001.

Vincent, W., Parker, A. and Adler, R., "Ambient Signals and Noise in the 915-MHz ISM Band," Conference on Factors Affecting the Reception of Radio Signals, Naval Postgraduate School, 5-6 March 2001.

Vincent, W., Adler, R. and Munsch, G., "Operation of a 2.4 GHz Portable Phone with Noise from a Microwave Oven," Conference on Factors Affecting the Reception of Radio Signals, Naval Postgraduate School, 5-6 March 2001.

Vincent, W., Adler, R. and Munsch, G., "The Temporal and Spectral Properties of Radio Noise from a Microwave Oven," Conference on Factors Affecting the Reception of Radio Signals, Naval Postgraduate School, 5-6 March 2001.

PROJECT SUMMARIES

OTHER:

Parker, A., Adler, R. and Vincent, W., "Parasitic Oscillations from an Active Television Antenna," prepared in cooperation with the Department of Oceanography, Naval Postgraduate School.

Vincent, W. and Munsch, G., "Power-Line Noise Mitigation Handbook for Naval and Other Receiving Sites," draft of 5th edition. (This handbook was extensively updated during the 2001 and it will be published in early 2002.)

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Radio Noise, Interference, Spectrum Signatures

FIRST PRINCIPLES PREDICTION OF X-RAY IMPULSE

Donald van Z. Wadsworth, Senior Lecturer

Department of Electrical and Computer Engineering and Space Systems Academic Group

Sponsor: Navy Strategic Systems Programs Office

OBJECTIVE: The multi-year objectives are: (i) collect and archive key data (reports and interviews) relevant to predicting the vulnerability of an RB aeroshell to an x-ray burst in space, (ii) compare the capability of existing physics-based models (finite-element hydrocodes and radiation deposition codes) to predict blow-off impulse and damage to various RB composite materials, (iii) modify a selected code to improve fidelity, (iv) validate the modified code against existing test data (UGT and AGT) and, if needed, plan and execute new tests using existing facilities (flash x-ray and surface loading), (v) establish a continuing core effort at NPS in support of SSP, involving faculty, graduate students, and coordination with related efforts at the DoE National Laboratories, DTRA, NNSA, NRL, and AFRL.

SUMMARY: Field trips to SSP headquarters, DTRIAC, and the National Laboratories (LANL, SNL, LLNL) resulted in a mine of documents covering the extensive restricted work in this field during the past 30 years. This together with extensive discussions with the experts at the various laboratories provided an ideal starting point for this project. With the support of key personnel at LLNL, as well as a Navy Master's Degree Thesis student and Professor Don Danielson (NPS Applied Mathematics Department), a weapons code was utilized to evaluate the shock impulse to a representative aeroshell due to a standard nuclear ABM threat model. Professor Knox Milsaps, Mechanical Engineering Department, is the co-advisor for the thesis.

After significant difficulty due to the different security organizations in DoE and DoD, DoE clearances were obtained for all involved and a classified mail channel was opened between LLNL and NPS, which is proving invaluable in pursuing this research project.

Installation at NPS of the SNL finite element hydrocode, CTH, was begun and will be evaluated during CY2002. Professor Danielson examined the commercial hydrocode, DYTRAN, for use in this project. Both CTH and DYTRAN will require addition of a radiation deposition module. A start was made in determining the suitability of using the NPS electron-beam machine for validating selected modeling code predictions. SNL colleagues suggested using their Z-pinch machine as a flash x-ray source for radiating aeroshell samples which were obtained from the SSP contractor.

DoD KEY TECHNOLOGY AREA: Other (Nuclear Weapons Effects, Hydrocodes)

KEYWORDS: Nuclear Weapons, X-Ray Radiation, Thermomechanics

PROJECT SUMMARIES

SILVACO TOOLS DEVELOPMENT FOR RADIATION EFFECTS

Todd Weatherford, Assistant Professor

Andrew Parker, Research Associate

Department of Electrical and Computer Engineering

Sponsors: Naval Surface Warfare Center – Crane Division

OBJECTIVE: To develop semiconductor simulation tools to improve modeling of radiation effects in semiconductor devices.

SUMMARY: Work in 2001 has continued on modeling radiation effects in Metal-Oxide-Semiconductor Silicon-on-Insulator (SOI) structures and charge trapping in buried oxides. The SOI modeling has been expanded to examine radiation effects on sense amps and analog circuitry for ferroelectric memories. Additional duties to test, model and design radiation hardened InGaAs photodetectors for InteFermetric Optical Guidance (IFOG) systems. A third project included in this research included the addition of characterizing ferroelectric capacitors.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Electronics, Materials, Processes and Structures, Modeling and Simulation

KEYWORDS: Electronics, Materials, Processes and Structures, Modeling and Simulation, Silicon-on-Insulator

SUPPORT FOR THE NPS LINEAR ACCELERATOR (LINAC)

Todd Weatherford, Assistant Professor

Andrew Parker, Research Associate

Department of Electrical and Computer Engineering

Sponsors: Various Activities

OBJECTIVE: Provide operation of the NPS LINAC and Flash X-ray facilities to internal and external users to study radiation effects in semiconductors and other materials.

SUMMARY: In 2001 both facilities have been maintained and improved for dosimetry. Over eight outside firms and three NPS researchers have utilized the facilities in CY01. The facilities have supported reimbursable research, which include student master theses.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Electronics

KEYWORDS: Radiation Effects, Electronics, Particle Accelerators, Materials, Semiconductors

AEA ARCHITECTURE AND PLATFORM MIXES

Lonnie A. Wilson, Research Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Air Systems Command

OBJECTIVE: The objective is to perform top level analysis of AEA (Advanced Electronic Attack) Architecture and Platform Mixes and identify key capabilities and needs to support the OSD AEA EA-6B follow-on studies.

SUMMARY: The EA-6B service life is through 2015–2020 requiring a follow-on platform or platform mix to the ICAP III upgrade expected to IOC in 2004. These efforts used the EA-6B ICAP III as a baseline to build a future Electronic Attack (EA) capability to accomplish the SEAD role and other Information Operation missions. This core tactical capability includes radar jamming, communication jamming, hard-kill capabilities, and connectivity to ISR and offboard assets. The expected results were a platform mix utilizing available technology to develop a system of systems to provide future EA capabilities.

PROJECT SUMMARIES

AEA candidate air vehicles are manned or unmanned, performing either the dedicated AEA role or having AEA capability as part of their multi-mission capability. The nature of AEA support requires detailed knowledge of the supported air, ground and sea forces and emerging warfighter concepts in Information Operations (IO).

The fundamental goal of the AEA was to find the most mission capable, cost effective solution to tactical aviation requirements for electronic warfare (EW) support. The initial requirement is driven by the necessity to replace an aging EA-6B airframe.

The architecture and preliminary design were completed for a digital ES (Electronic Support) receiver and processor for the AEA application. Technical performance improvements and new operational performance capabilities were identified. The AEA Technical Working Group agreed to develop the digital EC receiver along with high performance DSP with Specific Emitter Identification. NPS participated and supported the AEA Technical Working Group, the Digital Receiver Focus Group and the SEI Focus Group.

A new digital match filter concept was developed and demonstrated for the high performance detection and processing of LPI radar signals.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare, Other (Radar, Strike, and Surveillance)

KEYWORDS: EW, EA, Architecture, F-18G, UAV, UCAV, and IW

ELECTROMAGNETIC SUSCEPTIBILITY AND ANALYSIS OF CRITICAL INFRASTRUCTURE SYSTEMS

Lonnie A. Wilson, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Engineering Logistics Office

OBJECTIVE: The basic objective is to research the electromagnetic susceptibility of critical infrastructure systems.

SUMMARY: The research started the electromagnetic susceptibility and analysis of critical infrastructure systems. This initial research included the EM susceptibility and analysis for one infrastructure system.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare, Other (Information Warfare)

KEYWORDS: Electromagnetic, Radar, Electronic Warfare, IW

HIGH PERFORMANCE ELINT DEINTERLEAVER DEVELOPMENT

Lonnie A. Wilson, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: National Reconnaissance Office

OBJECTIVE: The basic objective is to develop a High Performance ELINT Deinterleaver (with contamination screening and deinterleaving processing) using classical and intrapulse parameters. This development builds on previous efforts including key technical feasibility demonstrations for High Performance ELINT SEI Processor.

SUMMARY: The NPS Deinterleaver is conceptually divided into two parts: 1) Preprocessor Section and 2) Deinterleaver Processor. Inputs to the deinterleaver include digitized IF from either pre-recorded standard data sets or operational feeds. Also, the Deinterleaver accepts optional AOA and TOA data.

Deinterleaver outputs include sorted Pulse Word Trains or Pulse Bursts to the SEI association algorithms. Also, deinterleaver pulse numbers and pulse parameter sets are passed to the IF Pulse Data Distribution for recording purposes, if desired.

From a single pulse, parameter estimates include: frequency, TOA, AOA, pulsewidth, risetime, amplitude modulation on pulse, phase modulation on pulse, frequency modulation on pulse, peak

PROJECT SUMMARIES

amplitude, pulse peak power, noise power, SNR. Also, interpulse parameters are derived from single pulse parameter information. Interpulse parameters include PRF, Scan and other parameters.

The Preprocessor Section includes: Digital Pulse Detection, Pulse Saturation and Minimum SNR Screen, Average Carrier Frequency Tune Error and Gross Interference Screen. The Deinterleaver Processor includes classical and MOP (intrapulse signals) Parameter Extractions, and Deinterleave Unit.

The Deinterleaver algorithms include classical and Modulation on Pulse (MOP) parameter extractions in the optimal characterization bandwidth, assignment of confidence to all measured parametrics, and a data formatting process. Angle of Arrival (AOA) centroiding and multi-channel complex voltage conjugates (phase & amplitude) will only be done in future development tasks. The NPS implementation has a single channel capable of batch processing output records to associate pulse descriptor words into bursts and trains using MOP parametrics and classical parameters, with confidence factors.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Sorting, ID, RF Receiver, MOP Signal Extraction, Parameter Extraction, Targeting

NPS STUDENT AND FACULTY HIGH POWER MICROWAVE (HPM) RESEARCH

Lonnie A. Wilson, Research Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Research Laboratory

OBJECTIVE: The basic objective of this research is to continue development of high power microwave (HPM) and ultra-wideband (UWB) technology and capabilities research at the Naval Postgraduate School including source and systems engineering and design, modeling and simulation and effects testing. This work will have application to ship defense, information warfare/information operations (IW/IO), and human-computer interface (HCI).

SUMMARY: Critical Infrastructure Protection (CIP) developments were performed using basic technology analysis and fundamental signal processing considerations for one infrastructure system. The NPS research used multiple signals from a specific electronic environment. SPY-1 radar and other radars were considered in the selected receiver system and processing results were analyzed.

DoD KEY TECHNOLOGY AREA: Human Systems Interface, Modeling and Simulation

KEYWORDS: HPM Source, Systems, Wideband, IW, IO

MOTION TRACKING USING INERTIAL SENSORS

Xiaoping Yun, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Chief of Naval Operations (N6M) and Army Research Office

OBJECTIVE: To develop a hybrid inertial/magnetic body tracking system for use in a networked virtual environment.

SUMMARY: An improved Magnetic, Angular Rate, Gravity (MARG) Body Tracking System was designed and implemented. The current MARG Body Tracking System is limited to tracking three limb-segments. The MARG sensors are physically connected to a desktop computer by cables. In this year, a multiplexing circuit was implemented to allow tracking of 15 limb-segments. Processing was moved from a desktop computer to a wearable computer and wireless communication was implemented using an IEEE 802.11b spread spectrum wireless LAN. The resultant system is able to track the entire human body and is untethered. The range of the system is the same as that of the wireless LAN which can be extended with the use of repeaters.

The second effort of this project was to develop a realistic human avatar to be interfaced with the MARG sensor system. With the continuing gain in computing power, bandwidth, and Internet popularity

PROJECT SUMMARIES

there is a growing interest in Internet communities. To participate in these communities, people need virtual representations of their bodies, called avatars. Creation and rendering of realistic personalized avatars for use as virtual body representations is often too complex for real-time applications such as networked virtual environments (VE). Virtual Environment (VE) designers have had to settle for unbelievable, simplistic avatars and constrain avatar motion to a few discrete positions. The approach taken in this project is to use a full-body laser-scanning process to capture human body surface anatomical information accurate to the scale of millimeters. Using this 3D data, virtual representations of the original human model can be simplified, constructed and placed in a networked virtual environment. The result of this project is to provide photo realistic avatars that are efficiently rendered in real-time networked virtual environments. The avatar is built in the Virtual Reality Modeling Language (VRML). Avatar motion can be controlled either with scripted behaviors using the H-Anim specification or real-time data from the MARG sensors. Live 3D visualization of animated humanoids is viewed in freely available web browsers.

PUBLICATIONS:

Marins, J.L., Yun, X., Bachmann, E.R., McGhee, R.B. and Zyda, M.J., "An Extended Kalman Filter for Quaternion-Based Orientation Estimation Using MARG Sensors," *Proceedings of the 2001 IEEE/RSJ International Conference on Intelligent Robots and Systems*, pp. 2003-2011, Maui, HI, 29 October-3 November 2001.

Bachmann, E.R., McGhee, R.G., Yun, X. and Zyda, M.J., "Inertial and Magnetic Posture Tracking for Inserting Humans into Networked Virtual Environments," *ACM Symposium on Virtual Reality Software and Technology (VRST'01) Proceedings*, pp. 9-16, Banff, Alberta, Canada, 15-17 November 2001.

THESES DIRECTED:

Hollis, P.G., "An Improved Magnetic, Angular Rate, Gravity (MARG) Body Tracking System," Masters Thesis, Naval Postgraduate School, June 2001.

Dutton, J.A., "Developing Articulated Human Models from Laser Scan Data for Use as Avatar in Real-time Networked Virtual Environments," Masters Thesis, Naval Postgraduate School, September 2001.

Aljuaied, A.M., "Bluetooth Technology and Its Implementation in Sensing Devices," Masters Thesis, Naval Postgraduate School, September 2001.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Motion Tracking, Inertial Sensors, Human Avatar, Wireless LAN

REDUCED CREW SIZE METROLOGY USING WIRELESS LANs AND WEARABLE PCs

Xiaoping Yun, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Surface Warfare Center

OBJECTIVE: To investigate the Reduced Crew Size (RCS) Metrology using WLANs and wearable computers.

SUMMARY: Working with the Measurement Science Directorate (MSD) of the Naval Surface Warfare Center (NSWC-Corona), feasibility of developing a general purpose calibration system using wearable computers and wireless LANs was studied. In particular, a prototype of pressure calibration system has been developed. The system includes a software module that makes it possible to submit calibration data to a remote server using wired or wireless LAN. The prototype system was demonstrated at the Fleet Maintenance Symposium at San Diego on 27-29 August 2001.

PROJECT SUMMARIES

THESIS DIRECTED:

Ly, T.T., "Shipboard Wireless Network Applications," Masters Thesis, Naval Postgraduate School, June 2001.

DoD KEY TECHNOLOGY AREA: Sensors.

KEYWORDS: Metrology, Wireless LAN, Wearable Computer

SUBMARINE WIRELESS LOCAL AREA NETWORKING

Xiaoping Yun, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Sea Systems Command

OBJECTIVE: To test and evaluate IEEE 802.11b compliant wireless LAN product components with respect to EMI/EMC for submarine damage control communications.

SUMMARY: A preliminary EMC study of COTS wireless LAN components was conducted. The difference between FCC Part 15 requirements and MIL-STD-461E requirements was investigated. It was noted that FCC Part 15 restrictions for radiated emissions are more stringent in the frequency ranges of 2.4 GHz and higher as compared to MIL-STD-461E. It was also noted that FCC Part 15 lacks sufficient requirements for susceptibility. Four tests of MIL-STD-461E (CE102, RE102, CS101, RS103) were conducted on the Aironet 4800 DS wireless LAN components. These four tests represent one in each of the required testing areas: conducted emissions, radiated emissions, conducted susceptibility, and radiated susceptibility. Based on these limited tests, it appears that the Aironet 4800 series of wireless LAN components are electromagnetically compatible with the submarine systems.

A Java based application for Damage Control (DC) communications was developed. The application uses multicast sockets to send standard DC and crew reports from handheld devices to the DCC console (see figure below) wirelessly.

OPNET Modeler 7.0B was used to produce a simulation of the proposed Virginia Class wired/wireless network, in the presence of a type load. The creation of a detailed 24-hour workload includes various combinations of HTTP, FTP, EMAIL, DB and Audio and Video to accomplish their tasks. This full workload was then applied to the built OPNET simulation. Subnet-to-Subnet throughput and application response time graphs show that the designed network would work well. Sensitivity analysis was also performed to determine when this system would fail by progressively increasing the full workload factor. This analysis showed that the system performs satisfactorily up to 152 wireless clients (each carrying a full workload). To provide an extra layer of validity to the simulation, an analytical model was developed for the longest path scenario and the Ethernet delay was compared. The results showed the simulation to be accurate based on similar Ethernet delays.

THESES DIRECTED:

Peck, E.A., "Analysis and Evaluation of the Electromagnetic Compatibility of COTS Wireless LAN Components Onboard Submarines," Masters Thesis, Naval Postgraduate School, September 2001.

Wilkins Jr., W.G., "Concepts, Applications and Analysis of a Submarine Based Wireless Network," Masters Thesis, Naval Postgraduate School, June 2001.

DoD KEY TECHNOLOGY AREA: Command, Control and Communication

KEYWORDS: Damage Control, Wireless Computer Networks

PROJECT SUMMARIES

COMPUTER AIDED DETECTION FOR THE SYNTHETIC APERTURE SONAR SYSTEM

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Sponsor: Naval Sea Systems Command

OBJECTIVE: Derive accurate equations that will allow one to compute the probability of detecting a mine-like- object (MLO) for a given probability of false alarm (false-alarm rate) for a given ocean environment. Work will begin on deriving an expression for the signal-to-interference power ratio (SIR) at the output of a correlator receiver that will take into account the propagation in the ocean medium of an acoustic signal from the transmit array to the target, and from the target back to the receive array. The probability of detection can be related to both the probability of false alarm and the SIR. Efforts will be made to express the SIR in terms of the complex scattering amplitude functions of different types of mines and ocean bottoms, and in terms of "target" and "reverberation" ambiguity functions.

SUMMARY: A set of pulse-propagation coupling equations was successfully derived. They couple the output electrical signal at a point element in a receive array to the transmitted electrical signal at the input to a transmit array via the complex frequency response of a fluid medium (e.g., air or water). The pulse-propagation coupling equations are based on linear, time-variant, space-variant, filter theory, the principles of complex aperture theory and array theory, and solving a linear wave equation, which includes satisfying all boundary conditions, including the boundary condition at the source. The time-variant, space-variant, complex frequency response of the ocean was shown to be the time-harmonic solution of a linear wave equation when the source distribution is a time-harmonic point source.

The pulse-propagation coupling equations provide a consistent, logical, and straightforward mathematical framework that can be used to accurately model the propagation of small-amplitude acoustic pulses in the ocean for a bistatic scattering problem. The main features of the pulse-propagation coupling equations are as follows: 1) transmitted electrical signals are modeled as amplitude-and-angle-modulated carriers, 2) both the transmit and receive apertures are modeled as volume, conformal arrays composed of unevenly-spaced, complex-weighted, point elements (this type of model for both of the apertures allows for maximum flexibility), 3) the complex weights are frequency dependent and allow for beamforming, 4) the performance of the point elements in both the transmit and receive arrays are characterized by frequency-dependent, transmitter and receiver sensitivity functions, and 5) the solution of a linear wave equation is given by the complex frequency response of the fluid medium. It is important to note that attention to all proper units of measurement were taken into account in order to ensure the accurate prediction of signal strength levels at each element in a receive array. This is especially important, for example, in order to obtain accurate probability of detection results.

Derivations of the complex frequency response of the ocean for the following three different bistatic scattering problems were performed: 1) no motion, 2) only the discrete point scatterer is in motion, and 3) all three platforms (the transmitter, discrete point scatterer, and receiver) are in motion. Specific examples on the use of the pulse-propagation coupling equations were given for the three different bistatic scattering problems. Scatter from a discrete point scatterer was modeled via the scattering amplitude function, which is a complex function (magnitude and phase) and is, in general, a function of frequency, the direction of wave propagation from the source to the scatterer, and the direction of wave propagation from the scatterer to the receiver. In addition to the scattering amplitude function, frequency-dependent attenuation was taken into account in order to model the propagation of sound from transmitter to discrete point scatterer, and from discrete point scatterer to receiver. The dimensionless, time-compression/time-stretch factor was derived and discussed for the two bistatic scattering problems involving motion. The time-compression/time-stretch factor takes into account the relativistic effects of motion and provides for accurate time delay and Doppler shift values.

PUBLICATION:

Ziomek, L.J., *Pulse Propagation and Bistatic Scattering*, Naval Postgraduate School Technical Report, NPS-EC-02-001, 26 October 2001.

PROJECT SUMMARIES

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Detecting Mine-Like Objects, Signal-to-Interference Power Ratio, Target Ambiguity Functions, Reverberation Ambiguity Functions

**DEPARTMENT OF
ELECTRICAL AND COMPUTER
ENGINEERING**

**2001
Faculty Publications
and Presentations**

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McEachen, J.C., *Online.ECE WWW Course Portal*: Established a consolidated course portal for EC web-based learning initiatives sponsored by COMSPAWARSSCOM. This course provided a focal point for electronic course materials developed within the EC department.

McEachen, J.C., *NSA Distance Learning Remote Computer Facility*: Installed and configured a system for Distance Learning students at the NSA to run EC computer assignments (MATLAB and OPNET) from their remote workcenter desktop by leveraging off research facilities locally. Facility included a WWW site for dissemination of class assignments, instructions, lecture notes, and software.

McEachen, J.C., *EC4960 Course Materials WWW Server*: (A resource containing complete collection of lecture notes, computer assignments, homework solutions, test keys, and software help manuals used to facilitate the instruction of EC4800. (<http://web.nps.navy.mil/~mceachen/ec4800/>)).

PUBLICATIONS/PRESENTATIONS

McEachen, J.C., EC3850 Course Materials WWW Server: A resource containing complete collection of lecture notes, computer assignments, homework solutions, test keys, and software help manuals used to facilitate the instruction of EC3850. (<http://web.nps.navy.mil/~mceachen/ec3850/>)

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**DEPARTMENT OF
ELECTRICAL AND COMPUTER
ENGINEERING**

Thesis Abstracts

THESIS ABSTRACTS

ULTRA-WIDEBAND ANTENNA DESIGN FOR THE USQ-146 INSTALLATION ON THE H-60 HELICOPTER

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The current configuration of the USQ-146 radio system on the H-60 helicopter uses two vertically-polarized transmit antennas and one vertically-polarized receive antenna. The purpose of this design is to replace the two existing transmit antennas with one vertically-polarized ultra-wideband omni-directional antenna for use on an H-60 equipped with a USQ-146 radio system. The antenna should have a VSWR less than three, ideally less than two, over the frequency range of 30-500 MHz. The antenna has to mount through an existing cargo hole and retract or fold for ten-inch ground clearance beneath the helicopter when landed. The H-60 3-D solid model was created with the MicroScribe-3DX digitizer, Rhinoceros NURBS modeling software V1.1 and Ansoft's High Frequency Structure Simulator (HFSS) Solid Modeler. The antenna was designed and its performance predicted using HFSS. HFSS is based on the finite element method and generates accurate results for realistic antennas. Three sizes of nine configurations of flat blade antennas were analyzed with HFSS. The successful design was an 88 cm tall bell-shaped flat blade antenna with a capacitive load on the end.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Information Warfare, Jamming, Antennas

ENGINEERING A WIRELESS DIGITAL NETWORK OPERATIONS CAPABILITY

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The abstract for this thesis is classified FOR OFFICIAL USE ONLY.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Wireless Local Area Network, WLAN, IEEE 802.11b, Digital Network Operations, DNO

BLUETOOTH TECHNOLOGY AND ITS IMPLEMENTATION IN SENSING DEVICES

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Bluetooth Wireless technology is the world's new short range RF transmission standard for small form factor, low cost, and short-range radio link between portable and desktop devices. This technology does not replace Wireless LANs rather it compliments them. Bluetooth wireless technology has many advantages over other Wireless LAN technologies, which makes it attractive to many applications. One such application is in the area of sensors and gauges on-board ships and submarines. If these are connected wirelessly, a huge amount of cables are eliminated and more user mobility is gained.

This thesis studies the theories and principles of Bluetooth technology and discusses the approaches of connecting Bluetooth to sensors and gauges. Some of the Bluetooth products available in the market were

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acquired for testing and evaluation. In the course of the study, it was found that the technology was not mainly developed with sensor and gauge applications in mind. However, integrating sensors with Bluetooth modules can be achieved by one of two approaches. One approach requires an expensive Development Kit and is limited to manufacturers integrating Bluetooth technology into their sensor products in compliance with Bluetooth Specifications. The other inexpensive approach requires custom circuit designing and program coding and is preferred by university researchers.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Motion Tracking, Wireless LAN, Bluetooth Wireless Technology

DESIGN, IMPLEMENTATION, AND TESTING OF A HIGH PERFORMANCE SUMMATION ADDER FOR RADAR IMAGE SYNTHESIS

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This thesis documents the schematic design, simulation, and fabrication mask layout of a high-speed 16-bit summation adder to be integrated into the Digital Image Synthesizer (DIS) Application Specific Integrated Circuit (ASIC). The DIS is a single-chip false target radar image generator to be used in countering wide band imaging radars. The DIS will calculate the false target image in 512 range bins. Each range bit utilizes two identical 16-bit binary adders. The 16-Bit Adder must compute the sum of two 16-bit numbers, providing a 16-bit sum, carry output, and overflow detection bit. The stated goal is for this adder to perform all of these functions in one pipeline stage while being clocked at 600 MHz. The first part of the design process includes an extensive analysis to utilize the fewest gates in designing the simplest adder that can achieve the 600 MHz goal. SPICE net lists are extracted from these schematic designs and simulations conducted to verify logic functionality and propagation speed. Mask layout of the verified design is constructed using a CMOS 0.18 micron process utilizing deep sub-micron technology with six metal interconnect layers. The mask layout design is verified by ensuring all design rule checks (DRC) and layout versus schematic (LVS) checks are satisfied. In addition, conclusions and recommendations are provided to assist other DIS project members in using this adder and the aforementioned design process for additional components of the DIS ASIC.

DoD KEY TECHNOLOGY AREAS: Sensors, Electronics, Computing and Software

KEYWORDS: Electronic Warfare, Radar Imaging, Digital Image Synthesizer Application Specific Integrated Circuit

MICROELECTRONICS REVERSE ENGINEERING: RECOVERING THE METAL 2 LAYER (U)

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The purpose of this research was to further the effort of microelectronics reverse engineering for the Department of Defense (DoD) toward the goal of evaluation and design verification of Integrated Circuits (ICs) fabricated and/or packaged in unclassified foundries. In particular, this research focused on enhancement of Scanning Electron Microscope (SEM) images to allow an accurate Graphical Data Stream II (GDSII) description to be made of the metal 2 (M2) layer of the Integrated Circuit (IC). This goal was accomplished through the use of the Adobe Photoshop tool, applied to three types of SEM images of the

THESIS ABSTRACTS

same area on the IC. The images were acquired with a SEM using a Backscattered Electron Detector, an In-Lens Detector, and a Secondary Electron Detector. Procedures for using Adobe Photoshop™ are detailed in this paper.

DoD KEY TECHNOLOGY AREAS: Electronics, Materials, Processes, and Structures

KEYWORDS: Microelectronics Reverse Engineering, Integrated Circuits, INFOSEC, Adobe Photoshop, SEM, RAITH, ESCOSY, GDSII

EVALUATION OF ALTERNATIVE COMMUNICATION SCHEMES USING ENVIRONMENTALLY ADAPTIVE ALGORITHMS

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Time-varying multipath propagation in a shallow underwater environment causes intersymbol interference in high-speed underwater acoustic (UWA) communications. Combating this effect is considered to be the most challenging task requiring large adaptive filters and increasing the computational burden at the receiver end.

This thesis presents results of an in-tank experiment and data analysis performed off-line to examine, evaluate, and compare the robustness of Time-Reversal Approach to Communications (TRAC) and the Matched Environment Signaling Scheme (MESS) in different conditions, such as noise, surface waves and range changes between the receiver and transmitter. Both methods examined can environmentally adapt the acoustic propagation effects of a UWA channel. The MESS method provides a communications solution with increased computational complexity at the receiver end but gives higher data rates and is more robust to the presence of noise, surface waves, and range changes than the TRAC method. On the other hand, the TRAC method manages to accomplish secure communications with low computational complexity at the receiver.

DoD KEY TECHNOLOGY AREA: Command, Control and Communications

KEYWORDS: Time Reversal Acoustics, Acoustic Communications, Acoustic Signal Processing, Acoustic Telemetry

PERFORMANCE AND SPACE BORNE APPLICATION ANALYSIS OF THE HIGHER ORDER CYCLOSTATIONARY BASED CLASSIFIER

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Second Reader: Tri T. Ha, Department of Electrical and Computer Engineering

Testing of the Higher Order Cyclostationary Based Classifier (HBC) is conducted to evaluate system operational performance. Utilizing Higher Order Cyclostationary (HOCS) analysis techniques, the HBC is designed to automatically detect and classify communication and radar signals contained in input signal samples. While test results utilizing earlier data were inconclusive on the effectiveness of the system, a more rigorous testing for Binary Phase-Shift Keying (BPSK) modulation scheme is herein carried out. The results of the HBC analysis reveal a system which experiences difficulty in performing modulation detection and classification of the input data at signal-to-noise ratios above 10 dB. The HBC automatic

THESIS ABSTRACTS

band-of-interest detector also shows evidence of interfering with accurate signal classification results. Recommended improvements to the algorithms and interface are presented to address these and other observed trends. An application of the HBC system to the Naval Research Laboratory's Pre-Configured Interface Payload (PCIP) program are assessed for space borne testing of the HBC system.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Computing and Software, Sensors, Modeling and Simulation

KEYWORDS: Cyclostationary, Cyclostationarity, Digital Signals, Signal Classification, Signals Intelligence (SIGINT), Spacecraft Payload Integration, Pre-Configured Interface Payload (PCIP)

PASSIVE TARGET TRACKING WITH UNCERTAIN SENSOR POSITIONS USING WAVELET-BASED TRANSIENT SIGNAL PROCESSING

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Doctor of Philosophy in Electrical Engineering-June 2001

Advisor: Murali Tummala, Department of Electrical and Computer Engineering

Committee Members: Charles W. Therrien, Department of Electrical and Computer Engineering

Jovan E. Lebaric, Department of Electrical and Computer Engineering

Thomas Hoffer, Department of Physics

Dr. Michael Shields, Michael Shields Inc.

This dissertation investigates the problem of tracking a maneuvering target from passive acoustic sensors of uncertain position. A batch oriented maximum a posteriori (MAP) algorithm using an expanded state vector is used to accurately estimate both the sensor's location and target trajectory from the data. Three sensor motion models are developed and compared under a variety of tracking scenarios. Additional tracking improvement is achieved through the use of transient signal processing. Two new wavelet-based time difference of arrival estimation methods are developed and compared to classical techniques. Testing on a variety of transient signals demonstrates that improved performance over the classical methods is achieved. The practicality and viability of the proposed techniques is confirmed through the modification and testing of a state of the art acoustic tracking system.

DoD KEY TECHNOLOGY AREA: Sensors, Target Tracking

KEYWORDS: Target Tracking, Non-Linear Estimation, Wavelet Analysis

POTENTIAL OPERATIONAL APPLICATIONS FOR HIGH POWER MICROWAVES

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This abstract is classified.

DoD KEY TECHNOLOGY AREAS: Human-Systems Interface, Modeling and Simulation

KEYWORDS: HPM Source, Systems, Wideband, IW, IO

THESIS ABSTRACTS

PREDICTION OF WIRELESS COMMUNICATION SYSTEMS PERFORMANCE IN INDOOR APPLICATIONS

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James Luscombe, Department of Physics

Due to a shift in the interest in wireless applications, from outdoor to indoor environments, new modelling solutions had to be designed to account for the immense complexity of the latter. Essentially, two categories of indoor propagation models prevailed until the mid-90s: the empirical and the physical models. They both predicted important characteristics of a given confined environment like the coverage area, transmitted power requirements, number and location of base stations or access points. The implementation of wireless communications systems onboard naval assets is expected to offer numerous advantages and enhance the existing shipboard communications systems. That, in turn, calls for a reliable and cost-effective means of estimating the expected link budget in such environments, especially when the infrastructure in question is yet to be built, as is the case in a ship class under development.

This thesis treats the problem of indoor propagation modeling using the Numerical Electromagnetic Code-Basic Scattering Code (NEC-BSC) and compares the predicted results obtained by this code with actual measurements performed inside a building at the Naval Postgraduate School. A number of important conclusions regarding the validity of NEC-BSC for indoor applications are being reached and some intriguing statistical results are being presented.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Simulation of Signal Propagation, Indoor Radio Propagation, NEC-BSC

MODELING DATA RATE AGILITY IN THE IEEE 802.11a WIRELESS LOCAL AREA NETWORKING PROTOCOL

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The IEEE 802.11a high-speed wireless local area networking (WLAN) protocol does not specify a mechanism for dynamically altering network data rates based on changing link conditions. This thesis first presents a baseline software model of the 802.11a protocol developed using the OPNET simulation tool. The model includes both the medium access control (MAC) and physical (PHY) layers of the standard. Two data rate agility mechanisms are then proposed and analyzed using the model. An infrastructure WLAN implementation of the baseline model is first simulated under standard network conditions to verify its operational characteristics and the results are presented. The model is then used to simulate two data rate agility mechanisms, one based on the link signal-to-noise ratio (SNR) and the other based on the frame loss rate at the transmitting station. Each technique is simulated using an infrastructure WLAN consisting of a fixed access point and a mobile workstation operating with standard network traffic loads. The results indicate that the link SNR is a better decision criterion for data rate agility than the frame loss rate. The design and methodology of this analysis provides insight into dynamic rate agility mechanisms and the criteria that may be used in developing future 802.11a-compliant hardware implementations.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Modeling and Simulation

KEYWORDS: Wireless, WLAN, Wireless LAN, Protocol, OPNET, 802.11a, OFDM, Rate Agility

THESIS ABSTRACTS

WEB-BASED TESTING TOOLS FOR ELECTRICAL ENGINEERING COURSES

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Master of Science in Computer Science-September 2001

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This thesis presents a distance-learning tool, which provides a self-sufficient application that allows one to implement online courses for electrical engineering. A major emphasis is placed on replacing simplistic multiple-choice or true-false test questions. A system named, Distance Learning Tools for Online Tests (DLTOT) is designed, modeled and implemented.

The implementation is based on the Java programming language, using Servlets and Java Server Pages (JSP), three-tier technology and Commercial-Off-the-Shelf (COTS) products, namely, an Apache web server, Tomcat Application server, Microsoft Access, Mathematica, WebMathematica and JSP/ Servlet technology.

DLTOT is able to control student access, to allow interaction with the student during the course, and to present a challenging test, which is easily graded by the application itself.

DoD KEY TECHNOLOGY AREAS: Manpower, Personnel and Training

KEYWORDS: Distance Learning, Distance Learning Tools for Online Tests, DLTOT

DESIGN OF A SYNCHRONOUS PIPELINED MULTIPLIER AND ANALYSIS OF CLOCK SKEW IN HIGH-SPEED DIGITAL SYSTEMS

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Digital systems implemented with high-speed transistor technologies face a variety of design challenges in an effort to keep pace with the accelerating demand for performance. As device switching frequencies climb comfortably into the gigahertz range, clock skew in digital systems threatens to limit the advantages of synchronous pipelined designs. This research investigates the limitations of clock skew on high-speed digital systems by designing and simulating an 8x8 bit synchronous, pipelined multiplier using Indium phosphide (InP), heterostructure bipolar junction (HBT) transistor technology. Fundamentals of circuit analysis and the principles of junction transistor behavior are applied to design an optimal family of logic devices using current-mode logic. All testing and simulation data is based upon results obtained from Tanner SPICE design tools. Using the building blocks of this logic family, an array multiplier is constructed and further configured into five distinct pipeline implementations. By employing a different number of pipeline stages in each implementation, the trade-offs of pipelining are illustrated and clock skew is analyzed at a variety of throughput rates. Finally, the impact of clock skew on throughput performance is quantified and summarized as a reference point for further research into asynchronous control techniques.

DoD KEY TECHNOLOGY AREA: Electronics

KEYWORDS: Clock Skew, Pipelined Logic Architecture, Current-Mode Logic, Indium-Phosphide Heterojunction Bipolar Transistors, High-Speed Logic

THESIS ABSTRACTS

DEVELOPMENT OF AN RF WEAPON USING OPEN SOURCE INTELLIGENCE

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Master of Science in Systems Engineering-September 2001

and

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The world's increasing reliance on computers and electronics has made the employment of radio frequency (RF) weapons against electronic systems an attractive concept. Electromagnetic interference (EMI) effects from RF radiation are well known. Recent advances in high-power microwave (HPM) technology and the increasing commercial availability of conventional RF sources have made the development of such systems for other than scientific pursuits not only feasible, but probable.

This thesis explores the technical requirements, costs, and timelines necessary to build such a system. It documents the processes that a team of "non-experts" undertook to design and build a microwave transmitter capable of disrupting unshielded electronic systems. The researchers investigated how to design and build a viable RF weapon capable of use in terrorist applications on a limited budget, with no external guidance from HPM experts, and using only open source information and Commercial-Off-The-Shelf (COTS) technology. This work documents useful sources of information, the development of a preliminary system design, the acquisition of components, and planning for system fabrication, component modification, and integration into a disguised mobile platform.

DoD KEY TECHNOLOGY AREAS: Electronics

KEYWORDS: Radio-Frequency Weapons, High-Power Microwave, Microwave Transmitter, Open Source Intelligence

SURVEY OF EMERGING WIRELESS/PCS TECHNOLOGY AND THE IMPLICATIONS ON FUTURE MILITARY TACTICAL COMMUNICATIONS

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This research evaluates the wireless technologies that are currently available in the commercial sector or that are in development. The objective is to evaluate the suitability of using the technologies as a viable communication vehicle for the United States Marine Corps, specifically for use by the Intelligence and Information Operations communities. Subjects addressed include cellular/personal communications services (PCS) technology currently available and in development. Also included are potential applications by the USMC, strengths and limitations as they relate to Intelligence and Information Operations, and relationships of cellular and PCS technologies. As a final point, recommendations for categorization of cellular/PCS technologies by radio frequency spectrum and wireless service are incorporated.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare

KEYWORDS: Intelligence, Information Operations, Personnel Communication Services, PCS, Cellular/PCS

THESIS ABSTRACTS

MEASUREMENTS AND MODELING ENHANCEMENTS FOR THE NPS MINIMUM RESOLVABLE TEMPERATURE DIFFERENCE MODEL, VISMODII

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Minimum Resolvable Temperature Difference (MRTD) measurement has long been used to describe the performance of thermal imaging systems. Computer models such as U.S. Army's FLIR92, that were developed to predict the MRTD, were reported to have deficiencies in dealing with sampling and aliasing effects. The models also include assumptions regarding the observer recognition process and therefore cannot predict the MRTD of an imager that incorporates an "objective" automatic target recognition device instead of a "subjective" human observer. The Visibility Model II developed for second generation thermal imaging systems at the Naval Postgraduate School (NPS) in the mid 90s takes sampling and aliasing issues into account and makes no assumptions about the observer. Modeling enhancements in VISMODII and its extension to predict objective MRTD are proposed and tested in this thesis. A parallel thesis at the NPS has shown that aliasing effects on image appearance are fundamentally different from noise. The improved VISMODII model accounts for the fact that unlike noise, aliasing may have a visual enhancing effect and therefore may lower MRTD. Experiments were conducted to measure subjective and objective MRTD. Experimental results demonstrated that the VISMODII model successfully predicts the MRTD both for the subjective and the objective schemes.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Thermal Imaging Systems, Minimum Resolvable Temperature Difference, MRTD, Visibility Model II, VISMODII

PERFORMANCE OF SERIALLY CONCATENATED CONVOLUTIONAL CODES WITH BINARY MODULATION IN AWGN AND NOISE JAMMING OVER RAYLEIGH FADING CHANNELS

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Doctor of Philosophy in Electrical Engineering-September 2001

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In this dissertation, the bit error rates for serially concatenated convolutional codes (SCCC) for both BPSK and DPSK modulation with different channel conditions and with (and without) spread spectrum are considered. For low signal-to-noise ratios, simulation results are used, while for higher signal-to-noise ratios, an average upper bound is developed to illustrate the achievable performance of SCCC. The theoretical bounds for SCCC BPSK and SCCC DPSK with AWGN, noise jamming, Rayleigh fading, and spread spectrum are developed, analyzed, and compared with simulation results. The differences in performance between SCCC BPSK and SCCC DPSK are described. Implications for the military communications user and jammer are also discussed.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare

KEYWORDS: Serially Concatenated Convolutional Codes, SCCC, BPSK Modulation, DPSK Modulation, Military Communications

THESIS ABSTRACTS

AUTOMATED SOFTWARE INTERFACE BETWEEN CEPXS AND SPICE

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Second Reader: Sherif A. Michael, Department of Electrical and Computer Engineering

Special purpose computer programs are essential to the design of semiconductor circuits that might be subjected to nuclear radiation either from the co-location to radiation sources or from the circuit being used in the space environment. Two such computer programs are the Coupled Electron-Photon Cross Section (CEPXS) and the Simulation Program with Integrated Circuit Emphasis (SPICE). This thesis describes the design and implementation of ASICS, an Automated Software Interface between CEPXS and SPICE (ASICS), which can be used to extract data automatically from the CEPXS output and modify a SPICE circuit description for analysis of potential radiation effects. Historically, this SPICE circuit description modification has been done manually. However, the complexity of large-scale integrated circuits and electronic systems dictates an automated interface between these two programs.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Electronics, Modeling and Simulation

KEYWORDS: Automated Software Interface, CEPXS, SPICE, ASICS, Coupled Electron-Photon Cross Section, Nuclear Radiation Effects, Space Radiation Effects, Radiation-Induced Parasitic Current, Semiconductor Devices

QUANTIFYING THE EFFECT OF CRYPTOLOGY AS A DECISION MAKING TOOL FOR THE NAVAL WARFIGHTER

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Master of Science in Space Systems Operations-September 2001

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John W. Van Hise, Jr., Department of Electrical and Computer Engineering

This abstract is classified.

DoD KEY TECHNOLOGY AREAS: Other (Information Superiority)

KEYWORDS: Cryptology, Signals Intelligence

AN INVARIANT DISPLAY STRATEGY FOR HYPERSPECTRAL IMAGERY

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Second Reader: Roberto Cristi, Department of Electrical and Computer Engineering

Remotely sensed data produced by hyperspectral imagers contains hundreds of contiguous narrow spectral bands at each spatial pixel. The substantial dimensionality and unique character of hyperspectral imagery requires display techniques that differ from traditional image analysis tools.

This study investigated the appropriate methodologies for displaying hyperspectral images based on the physical principles of human color vision and a generalized set of linear transformations. Principal components (PC) analysis is a powerful tool for reducing the dimensionality of a data set, and PC-based strategies were explored in creating a broadly applicable image display strategy. It is shown that the invariant display strategy and generalized eigenvectors developed within this study offer a first look capability for a wide variety of spectral scenes. PC transformations utilizing this generalized set of eigenvectors allow for 'real time' initial classification. Detailed investigation of the relationship between the

THESIS ABSTRACTS

PC eigenvectors and dissimilar image content shows that this strategy is robust enough to provide an accurate initial scene classification.

DoD KEY TECHNOLOGY AREAS: Sensors, Human Systems Interface

KEYWORDS: Spectral Imagery, Display Strategies, Colorimetric Representations, Hyperspectral Analysis

THERMINATOR 2: DEVELOPING A REAL TIME THERMODYNAMIC BASED PATTERNLESS INTRUSION DETECTION SYSTEM

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Master of Science in Computer Science-September 2001

and

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Master of Science in Systems Engineering-September 2001

Master of Science in Computer Science-September 2001

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LCDR Chris Eagle, USN, Department of Computer Science

A novel system for conducting non-signature based, or patternless, intrusion detection of computer networks is presented. This system uses principles of thermodynamics to model network conversation dynamics. A notion of baseline operating conditions is developed by observing the properties of entropy, energy and temperature within the system. Perturbations in these properties are considered potential intrusions for further investigation. This thesis focuses on the design and architecture of this system. System functions are decomposed into a network sensing device, a real-time processing component and a forensics component. A mechanism for forwarding and storage of sensed data is developed and discussed. Similarly, a novel three-dimensional display technique and the data structure that allows direct access of raw packet information from energy levels within this display is constructed and discussed. A system configuration language is defined and presented and additional tools for follow-on forensic analysis are developed. Finally, examples of valid intrusions and other network perturbations in real traffic collected in Department of Defense network operation center backbones are presented. Preliminary results indicate this system has significant potential for revealing anomalies in large network systems.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Modeling and Simulation, Computing and Software

KEYWORDS: Intrusion Detection, Thermodynamics, High-Speed Networking, Network Sensing Device

THE DESIGN AND IMPLEMENTATION OF A REAL-TIME DISTRIBUTED APPLICATION EMULATOR

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Master of Science in Electrical Engineering-March 2001

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Second Reader: Jon Butler, Department of Electrical and Computer Engineering

This thesis details the engineering, design and implementation of a real-time, distributed, application emulator system (AE system). The project had two main goals for the tool: emulation of real-time distributed systems, and as a programmable resource consumer. The AE system is currently being used in the HiPer-D test bed to activate a resource leveling tool that monitors several software components for real-time response. The AE system is highly flexible and can be used in the context of a variety of network

THESIS ABSTRACTS

topologies and system loading options. The results presented show that the AE system also emulates distributed systems.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Software Emulation, Real-Time Benchmarks

DEVELOPING ARTICULATED HUMAN MODELS FROM LASER SCAN DATA FOR USE AS AVATARS IN REAL-TIME NETWORKED VIRTUAL ENVIRONMENTS

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With the continuing gain in computing power, bandwidth, and Internet popularity, there is a growing interest in Internet communities. To participate in these communities, people need virtual representations of their bodies, called avatars. Creation and rendering of realistic personalized avatars for use as virtual body representations is often too complex for real-time applications such as networked virtual environments (VE). Virtual Environment (VE) designers have had to settle for unbelievable, simplistic avatars and constrain avatar motion to a few discrete positions.

The approach taken in this thesis is to use a full-body laser-scanning process to capture human body surface anatomical information accurate to the scale of millimeters. Using this 3D data, virtual representations of the original human model can be simplified, constructed and placed in a networked virtual environment.

The result of this work is to provide photo realistic avatars that are efficiently rendered in real-time networked virtual environments. The avatar is built in the Virtual Reality Modeling Language (VRML). Avatar motion can be controlled either with scripted behaviors using the H-Anim specification or via wireless body tracking sensors developed at the Naval Postgraduate School. Live 3D visualization of animated humanoids is viewed in freely available web browsers.

DoD KEY TECHNOLOGY AREAS: Sensors, Modeling and Simulation

KEYWORDS: Motion Tracking, Inertial Sensors, Human Avatar, Virtual Environments

2-D MODELING OF GAN HEMTS INCORPORATING THE PIEZOELECTRIC EFFECT

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Second Reader: Harry Dietrich, Naval Research Laboratory

Gallium Nitride (GaN) High Electron Mobility Transistors (HEMTs) are radio frequency power amplifiers that promise to revolutionize the capability of Navy radar systems. The Office of Naval Research is currently funding basic research of developing microwave power amplifiers for use in future radar systems. This thesis incorporates piezoelectric (PZ) equations in the Silvaco AtlasTM software for modeling GaN/AlGa^N structures. The PZ effect enhances a two dimensional electron gas at the GaN/AlGa^N interface due to stress induced polarization.

DoD KEY TECHNOLOGY AREAS: Electronics, Materials, Processes, and Structures, Modeling and Simulation

KEYWORDS: Gallium Nitride, High Electron Mobility Transistor, Piezoelectric Effect

THESIS ABSTRACTS

FEASIBILITY ANALYSIS AND DESIGN OF A FAULT TOLERANT COMPUTING SYSTEM: A TMR MICROPROCESSOR SYSTEM DESIGN OF 64-BIT COTS MICROPROCESSORS

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**Advisors: Alan A. Ross, Navy Tactical Exploitation of National Capabilities (TENCAP) Chair
Herschel H. Loomis, Department of Electrical and Computer Engineering**

The purpose of this thesis is to analyze and determine the feasibility of implementing a fault tolerant computing system that is able to function in the presence of radiation induced Single Event Upsets (SEU) by using the Triple Modular Redundancy (TMR) technique with 64-bit Commercial-off-the-Shelf (COTS) microprocessors.

Due to the radiation environment in space, electronic devices must be designed to tolerate the radiation effects. While there are radiation-hardened devices that can tolerate radiation effects, they offer lower performance and higher cost than COTS devices. On the other hand, COTS devices offer lower cost, orders of magnitude higher performance, shorter design time and better software availability and compatibility. However, COTS devices are susceptible to the radiation effects. In order to use COTS devices in space environment, a fault tolerance technique such as TMR needs to be implemented.

This thesis presents the design and analysis of a TMR 64-bit COTS microprocessor implementation. The system incorporates three 64-bit microprocessors, the memory system including SRAM and PROM memory modules and the programmable logic devices that are used to implement the TMR technique. The validity of the design is verified by the timing analysis conducted on read and write operations.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Electronics

KEYWORDS: Fault Tolerant Computing, Triple Modular Redundancy (TMR), Commercial-off-the-Shelf (COTS) Devices, Single Event Upsets (SEU)

A PATHFINDER FOR A MULTI-INT INFORMATION ARCHITECTURE

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Alan A. Ross, Navy Tactical Exploitation of National Capabilities (TENCAP) Chair**

Today's intelligence data management systems are not scalable and flexible enough to meet 21st century warfighter requirements. There is little or no information sharing between the producers of intelligence, perpetuating them as islands (stovepipes) of information. Web technologies offer an improvement over existing intelligence information management systems by providing loosely-coupled connectivity through the use of hypertext transfer protocol (HTTP) and markup language (HTML). But web-based implementations still fall far short of satisfying the majority of requirements posed by intelligence community users. What is needed is a flexible distributed architecture that leverages existing assets and the benefits of web technologies, while providing needed improvements that better address the need for multi-intelligence interoperability.

This thesis applies a systematic requirement-driven approach to define a pathfinder for a multi-intelligence information architecture. The pathfinder concept is discussed as a necessary acquisition tool to help bound and scale a realistic solution. Key enabling information technologies are evaluated and recommended as a foundation for implementation. A case study is presented to show proof-of-concept and progress toward achieving a multi-intelligence information architecture.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREAS: Computing and Software, Human Systems Interface, Other (Information Technology)

KEYWORDS: Enterprise Computing, Object-Oriented Systems, Distributed Processing, Common Object Request Broker Architecture (CORBA), Java, Extensible Markup Language (XML), Object Databases, Ontology

WEARABLE HF ANTENNA FOR NAVAL POSTGRADUATE SCHOOL COMWIN SYSTEM

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B.S.E.E., Naval Postgraduate School, 1999

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Second Reader: Richard W. Adler, Department of Electrical and Computer Engineering

Researchers at the Naval Postgraduate School (NPS) have proposed a Combat Wear Integration (COMWIN) antenna system that includes three separate antennas for the man-portable implementation of the Joint Tactical Radio System (JTRS). The COMWIN system incorporates wideband antennas into the warrior's combat clothing in order to make the radio operator indistinguishable on the battlefield. The three antennas cover the frequency ranges: 2-30 MHz, 30-500 MHz, and 500-2000 MHz. This thesis describes the man wearable HF antenna designed to operate from 2-30 MHz for use by dismounted warriors in all combat environments. The antenna was designed and its performance predicted using Ansoft's High Frequency Structure Simulator (HFSS) and Nittany Scientific, Inc.'s Graphical Numerical Electromagnetics Code (GNEC). Measurements of the prototype showed good agreement with theoretical predictions. The HF antenna must operate with an inductive Automatic Tuning Unit (ATU). Coupling between the antenna and a human body effects antenna input impedance. Placing the antenna on a human limits the antenna conductor electrical path length at the frequencies of operation. For the optimum antenna location, an analysis of the antenna design is conducted for seven different types of soil. The antenna must operate from 2-30 MHz with a Voltage Standing Wave Ratio (VSWR) less than three for a 50 (coaxial cable, have low visual signature, be vertically polarized, have coverage from 0 to 60 degrees above the horizon and 0 to 360 degrees in azimuth. Input impedance and radiation patterns are determined for the antenna using the GNEC and HFSS.

DoD KEY TECHNOLOGY AREAS: Battle Space Environments, Clothing, Textiles and Food, Command, Control and Communications, Electronics, Electronic Warfare, Modeling and Simulation, Manufacturing Science and Technology

KEYWORDS: HF Antenna, Wearable Antenna, Numerical Electromagnetics Code (NEC), Method of Moments, Combat Wear Integration

SECURITY OF CODE-DIVISION MULTIPLE ACCESS (U)

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William W. Brandenstein, National Security Agency

Second Reader: Tri T. Ha, Department of Electrical and Computer Engineering

With the shift of the defense industry from developing Government-off-the-shelf (GOTS) equipment to engineering current and new commercial products and technology into pre-existing and new government communication products along with the growing popularity of wireless mobile communication, a look at the security of code-division multiple access (CDMA) - a current and future wireless multiple access technology - in the context of the tactical battlefield is the focus of this paper.

THESIS ABSTRACTS

After identifying the security weaknesses of CDMA in the context of the Global Information Grid (GIG) - an environment to support tactical communication networks - technologies to minimize or overcome the vulnerabilities are presented for the tactical commander to employ or implement.

Additionally, the effect of pulse jamming on a IS-95 like CDMA system is analyzed. Graphs are provided to show how the probability of bit error due to the pulse jammer is directly influence by the power of the transmitter.

DoD KEY TECHNOLOGY AREAS: Other (Global Information Grid, Wireless Communication)

KEYWORDS: Code-Division Multiple Access (CDMA), Global Information Grid (GIG), Tactical Battlefield, Security Services, Hard Decision Decoding

OPTIMIZATION OF MULTIPLE PLATFORM PRECISION GEOLOCATION THROUGH COMPUTER SIMULATION

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Master of Science in Physics-June 2001

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Donald L. Walters, Department of Physics

Gerry Baumgartner, Space and Naval Warfare Systems Command

The fundamental mathematical relationships that govern Time Difference of Arrival (TDOA) geolocation suggest that to reduce the positional uncertainty in the target, the baseline between the two collectors can be lengthened. A multiple-platform precision geolocation system is modeled using Operational Performance Simulation (OPS) software and tested with various baseline lengths to determine the impact on system performance.

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Space Vehicles, Command, Control and Communications, Electronic Warfare, Sensors, Modeling and Simulation

KEYWORDS: Computer Simulation, Unmanned Aerial Vehicles, Precision Geolocation

PERFORMANCE ASSESSMENT OF AN INTRAPULSE TECHNIQUE TO IDENTIFY AND DEINTERLEAVE RADAR SIGNALS

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Master of Science Electrical Engineering-December 2000

Advisor: Lonnie A. Wilson, Department of Electrical and Computer Engineering

Second Reader: Herschel H. Loomis Jr., Department of Electrical and Computer Engineering

The Wilson Advanced Specific Emitter Identification (SEI) Algorithm with Adaptive Thresholds is evaluated using live radar data. The objective is to determine performance of the algorithm in a low signal to noise ratio (SNR) environment, compare the performance to that of an intrapulse frequency based approach and explore implementation of the algorithm in deinterleaving applications. Utilizing unintentional Phase Modulation on the Pulse (PMOP) as an identification feature and adaptive thresholds in the classifier, the algorithm is designed to identify radar signals based on single pulse analysis. Earlier efforts have demonstrated the efficacy of using PMOP versus frequency modulation on the pulse (FMOP) and the technique's effectiveness against lab generated signals in low SNR conditions. This work tests the technique utilizing live radar data. Live radar data of marine navigation radars with similar conventional parameters collected by the Naval Research Laboratory served as the data set for the test. The SEI results of the live radar testing confirm the algorithm performs well on a single pulse basis in relatively low SNR environments. Additionally, use of PMOP in the algorithm results in a 3-4 dB SNR performance gain over FMOP. A conceptual deinterleaving architecture, which incorporates the technique, is developed.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Command, Control, and Communication, Electronics, Electronic Warfare, Sensors, Space Vehicles

KEYWORDS: Specific Emitter Identification, Deinterleaving, Intrapulse, Unintentional Modulation on the Pulse, Pattern Recognition, Signal Classification, SNR

MEANS OF COVERT COMMUNICATIONS

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Master of Science in Electrical Engineering-September 2001

Advisor: John McEachen, Department of Electrical and Computer Engineering

Second Reader: Murali Tummala, Department of Electrical and Computer Engineering

Steganography is the "art" of hiding information so that the information's very existence is not detected. As a method of covert communications, steganography is used to hide information within other communications media. This thesis examines the various techniques of hiding information within Local Area Network (LAN) or Wide Area Network (WAN) communications traffic, with special emphasis on typical internetwork traffic using the Transmission Control Protocol (TCP) and Internet Protocol (IP). Current means of steganography within network traffic is limited in terms of throughput and robustness. A novel means of covertly transmitting data within TCP segments is presented which demonstrates how manipulating TCP error handling should increase the effective throughput of covertly transmitted data significantly. A new TCP data hiding application was developed to embed the hidden information into the cover media, and to retrieve the information at the receiving end. A flexible testing architecture was designed and implemented that may also be used to test other steganographic techniques. Error handling techniques for the hidden information were identified for the steganographic protocol, to increase the robustness of the hidden information. Finally, steganalytic techniques and tools have been identified to counter the use of this technique by unfriendly forces.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Modeling and Simulation, Computing and Software

KEYWORDS: Local Area Networks, LAN, Wide Area Networks, WAN, Transmission Control Protocol, TCP, Steganography

DESIGN OF MOBILE USER OBJECTIVE SYSTEM (MUOS) HELMET MOUNTED UHF ANTENNA

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Master of Science in Information Technology Management-September 2001

Advisors: Jovan Lebaric, Department of Electrical and Computer Engineering

John Osmundson, Department of Information Science

The Mobile User Objective System (MUOS) is the Navy's next generation narrowband tactical communication system that will provide a significant increase in capacity and link availability to disadvantaged users, including handheld terminals. Future MUOS antennas will have a receive band of 243 MHz - 270 MHz and a transmit band of 292 MHz - 317 MHz with a voltage standing wave ratio (VSWR) of less than three across both bands. Additionally, the antenna must have a nearly omni-directional radiation pattern above 10 degrees in elevation, be conformal to a U.S. military helmet and have a low profile. In this thesis an antenna was designed that is capable of operating over the entire band 243 MHz to 317 MHz. The antenna performance was optimized for its design restrictions. The antenna was designed and its performance predicted using Ansoft's High-Frequency Structure Simulator (HFSS). The HFSS is based on the Finite-Element Method (FEM).

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Antennas, Tactical Communications System, Mobile User Objective System, MOUS

DESIGN AND EXPERIMENTAL EVALUATION OF AN ELECTRO-OPTICAL, SIGMA-DELTA MODULATOR FOR WIDEBAND DIGITAL ANTENNAS

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John P. Powers, Department of Electrical and Computer Engineering

Electro-optical sigma-delta ((() analog-to-digital converters (ADCs) use a pulsed laser to oversample an input signal at two Mach-Zehnder interferometer modulators. A fiber lattice accumulator is embedded within a feedback loop around a single-bit quantizer to spectrally shape the quantization noise to fall outside the signal band of interest. Applications of electro-optical ((ADCs include digitizing wideband radio frequency signals directly at an antenna (digital antenna). The design considerations, construction process and experimental evaluation of the electro-optical ?? ADC are presented. The experimental results are compared with a computer model of the electro-optical ???sampling and digitization process.

DoD KEY TECHNOLOGY AREAS: Electronics, Electronics Warfare, Sensors, Other (Electro-Optics)

KEYWORDS: Sigma-Delta, Optical Sampling, Analog-to-Digital Converters, Optical ADC, Electro-Optical, Digital Antennas, Fiber Lattice, Mach-Zehnder Interferometers

EFFECTIVENESS OF THE HARM AS EMPLOYED BY THE F-16CJ AIRCRAFT AGAINST SERBIAN THREAT AND EARLY WARNING RADAR DURING OPERATION ALLIED FORCE

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LtCol Mark A. Kanko, USAF, Air Force Information Warfare Center

The purpose of this thesis is to quantify the effectiveness of HARM Employment by F-16CJ aircraft against Serbian Threat and EW radars during OPERATION ALLIED FORCE (OAF) of March-June 99. The effectiveness was determined primarily through the use of "all-source" data to confirm the suppression/damage that target radars may have suffered and to assess general radar activity impacts as a whole during the conflict. The factors that enhance or degrade HARM effectiveness were also investigated as well as strike aircraft impacts where possible. Due to the impact that fog of war has on obtaining specific technical data, the emphasis of the report is on the apparent effect of the HARM on the enemy air defenses during the course of a mission (and campaign) and not the technical aspects of HARM performance during an engagement. However, modeling of several of the individual mission incidents was accomplished. In these cases, MESA 5.1.3 (Model for Electronic Support and Attack) was used to model the airborne receivers/ground emitters, calculate propagation losses, and verify scenario geometry to determine signal strength levels at the airborne receivers of interest.

DoD KEY TECHNOLOGY AREA: Electronic Warfare

KEYWORDS: F-16CG, High-Speed Anti-Radiation Missile, Air War Over Serbia

THESIS ABSTRACTS

VULNERABILITY ASSESSMENT THROUGH PREDICTIVE MODELING OF IEEE 802.11 STANDARD WIRELESS LOCAL AREA NETWORKS

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Master of Science in Systems Technology-June 2001

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CAPT James R. Powell, USN, Information Warfare Academic Group**

The development of the IEEE 802.11 standard for wireless local area networks (WLANs) has greatly accelerated the commercial development of wireless technology for enterprise network solutions. Government and military organizations are also benefiting from the competition and interoperability fostered under the international standard. Given the decreasing cost, and proliferation of wireless networking technology, organizations are foregoing the expansion of cumbersome ethernet networks, and turning to cheap, available wireless architectures to augment data communication and processing needs.

Wireless technology availability coupled with the U.S. military's trend of looking to commercial-off-the-shelf (COTS) communication and computing solutions necessitate an awareness of the characteristics of WLANs. The argument for research is bolstered when considering how the ease of implementation and low system maintenance costs make it probable that second or third world entities at odds with US interests may use COTS wireless technology. Should the U.S. confront adversaries that have integrated command and control circuits consisting of WLANs, or come under attack from groups that know how to exploit our own, it will be necessary to have analyzed WLAN characteristics.

This thesis intends to research the current industry technology and standards driving WLAN interoperability, and determine which vendor's components are likely to be seen in world markets. Finally, the thesis will analyze a WLAN communications link at NPS to determine feasibility of emissions/intercept field mapping using a modular software and hardware suite.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Computing and Software, Electronics, Electronic Warfare, Sensors, Other (Wireless LANs)

KEYWORDS: Wireless Local Area Networks, IEEE 802.11, Exploitation, Vulnerability, Link Analysis, Radio Propagation, Network Security, Information Operations

WIRELESS TECHNOLOGY VIA SATELLITE COMMUNICATIONS FOR PEACEKEEPING OPERATIONS

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Master of Science in Information Technology Management-September 2001

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How can reliable information be shared amongst international, military, and non governmental organizations in support of peacekeeping operations? This thesis examines a wireless alternative to enhance existing communication infrastructures as a primary means of information exchange. When assessing the need for wireless and making a determination of its use, a study of its markets, trends, future growth, policies, and regulations must be taken into consideration. Wireless technology via satellite communications can offer a great advantage of information exchange for mobility-deployed organizations requiring extensive geographical coverage such as peacekeeping operations. With the emergence of higher transmission rates and technological options (i.e. video conferencing, Wide Area Networking, internet accessibility, voice/fax/data transfer, etc.) for satellite communication, the examination of wireless technology and the options it presents becomes paramount. Peacekeeping efforts involve the coordination and collaboration of civilian/military organizations that depend exclusively on information exchange for rapid response and operational readiness. The use for wireless as a necessary communication requirement will aid in the achievement of these objectives.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREAS: Other (Information Operations)

KEYWORDS: Wireless Technology, Satellite Communications

FEASIBILITY STUDY OF SPEECH RECOGNITION TECHNOLOGIES FOR OPERATING WITHIN A MEDICAL FIRST RESPONDER'S ENVIRONMENT

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Ray T. Clifford, Defense Language Institute

Douglas E. Brinkley, Department of Systems Management

This thesis was designed to address some of the issues facing the medical First Responder who is continually tasked with providing care within multi-national environments. Currently, there are no established billets or quota requirements at the Defense Language Institute Foreign Language Center for Navy Corpsmen for the purposes of foreign language education prior to an overseas assignment or deployment.

The primary Speech Recognition (SR) device used in this study was the Voice Response Translator (VRT). Navy Corpsmen and Army Medics were asked to evaluate the VRT's capabilities in assisting with non-English speaking patient assessments. Other SR assisted technologies available to overcome some of the burden of providing healthcare in a foreign language environment were also studied. The results of this feasibility study show that SR assisted technologies are a viable tool available for operation within a medical First Responder's environment.

DoD KEY TECHNOLOGY AREAS: Manpower, Personnel, and Training, Computing and Software

KEYWORDS: Speech Recognition, Machine Translation, Field Medicine, Medical

CLASSIFICATION OF DIGITAL MODULATION TYPES IN MULTIPATH ENVIRONMENTS

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Electrical Engineer-March 2001

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Tri T. Ha, Department of Electrical and Computer Engineering

Roberto Cristi, Department of Electrical and Computer Engineering

As the expansion of digital communication applications still continues, the need for automated classification of digital modulation types increases. This study attempts to give a partial solution to this problem by proposing a classification scheme which identifies nine of the most popular digital modulation types; namely 2-FSK, 4-FSK, 8-FSK, 2-PSK, 4-PSK, 8-PSK, 16-QAM, 64-QAM and 256-QAM. Higher-order statistics parameters are selected as class features, and a hierarchical neural network-based classifier set-up proposed for the identification of all modulation types considered except those within the M-QAM family. Specific M-QAM types identification is obtained via equalization-based schemes. This study considers the effects due to real-world multipath propagation channels and additive white Gaussian noise. Results show a consistent overall classification performance of at least 68% for severe multipath propagation models and for SNR levels as low as 11dB.

DoD KEY TECHNOLOGY AREAS: Electronics, Electronic Warfare

KEYWORDS: Digital Modulations, Propagation Channels, Moments, Cumulants, Neural Networks, Classification

THESIS ABSTRACTS

COMPLETION AND TESTING OF A TMR COMPUTING TESTBED AND RECOMMENDATION FOR A FLIGHT-READY FOLLOW-ON DESIGN

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Herschel H. Loomis, Jr., Department of Electrical and Computer Engineering**

This thesis focuses on the completion and hardware testing of a fault tolerant computer system utilizing Triple Modular Redundancy (TMR). Due to the radiation environment in space, electronics in space applications must be designed to accommodate single event phenomena. While radiation hardened processors are available, they offer lower performance and higher cost than commercial off the shelf processors. In order to utilize non-hardened devices, a fault tolerance scheme such as TMR may be implemented to increase reliability in a radiation environment. The design that was completed in this effort is one such implementation.

The completion of the hardware design consisted of programming logic devices, implementing hardware design corrections, and the design of an overall system controller. The testing effort included basic power and ground verification checks to programming, executing, and evaluating programs in read only memory. During this phase, additional design changes were implemented to correct design flaws.

This thesis also evaluated the preliminary design changes required for a space implementation of this TMR design. This included design changes due to size, power, and weight restrictions. Additionally, a detailed analysis of component survivability was performed based on past radiation testing.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Computing and Software, Electronics

KEYWORDS: Fault Tolerant Computing, Triple Modular Redundancy (TMR), Commercial-off-the-Shelf (COTS) Devices, Single Event Upsets (SEU)

COMPUTER NETWORK DEFENSE: A SURVEY OF NETWORK TRACING TECHNIQUES

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Master of Science in Systems Technology-June 2001

**Advisors: CAPT James Powell, USN, Information Warfare Academic Group
John McEachen, Department of Electrical and Computer Engineering**

With the growth of the Internet, the World Wide Web, and digital networks throughout the Department of Defense (DoD), the amount of information and resources available nearly instantaneously greatly impacts operations within DoD and each service. Because of this impact, the reliability, integrity and availability of data has become critical to the success of the Department's mission. As part of the security posture of DoD, a layered defense is integrated into its digital networks, which is implemented as a passive measure to meet DoD's security needs. These defenses, however, are able to identify the origin of attacks only after traditional investigative techniques are employed. This thesis looks at all of the research being conducted in academia, in the commercial sector, and within the government to address the traceback problem, the means to identify an attacker's Internet source location via automated methods.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Computing and Software, Sensors, Other (Computer Security, Information Operations)

KEYWORDS: Traceback, CNA, CNE, CND, Network Security, DNO, IO

THESIS ABSTRACTS

AN IMPROVED MAGNETIC, ANGLE RATE, GRAVITY (MARG) BODY TRACKING SYSTEM

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**Master of Science in Electrical Engineering-June 2001
Electrical Engineer-June 2001**

**Committee Chair: Xiaoping Yun, Department of Electrical and Computer Engineering
Committee Members: Sherif Michael, Department of Electrical and Computer Engineering
Eric R. Bachmann, Department of Computer Science**

This thesis proposes the design of an improved Magnetic, Angular Rate, Gravity (MARG) Body Tracking System. The current MARG Body Tracking System is limited to tracking three limb-segments. The MARG sensors are physically connected to a desktop computer by cables.

In this thesis, a multiplexing circuit was implemented to allow tracking of 15 limb-segments. Processing was moved from a desktop computer to a wearable computer and wireless communication was implemented using an IEEE 802.11b spread spectrum wireless LAN. The resultant system is able to track the entire human body and is untethered. The range of the system is the same as that of the wireless LAN which can be extended with the use of repeaters. This thesis work will ultimately allow human insertion into virtual environments for training and other applications.

DoD KEY TECHNOLOGY AREA: Computing and Software, Human System Interface, Sensors

KEYWORDS: Human Body Tracking

AN ARCHITECTURE FOR ANALYSIS AND COLLECTION OF RF SIGNALS USED BY HAND-HELD DEVICES IN COMPUTER COMMUNICATIONS

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Master of Science in Electrical Engineering-March 2001

**Advisors: John C. McEachen, Department of Electrical and Computer Engineering
Second Reader: Murali Tummala, Department of Electrical and Computer Engineering**

This thesis studies the wireless communications aspects of an Internet-connected hand-held device. It reviews the multipath effects of RF propagation and provides a detailed analysis of the Mobitex network protocols. Field experiments were conducted to measure the signal strength of indoor and outdoor reception. A framework for using real-time wireless communications analysis equipment for the collection of this RF signal is designed and discussed. Expected results from the collection of this signal data are presented.

DoD KEY TECHNOLOGY AREA: Other (Wireless Communications, Computer Communications)

KEYWORDS: Wireless Communications, Mobile Data, RF Signal

RADAR TARGET IMAGING USING TIME-REVERSED PROCESSING

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Master of Science in Systems Engineering-September 2001

**Advisor: Michael A. Morgan, Department of Electrical and Computer Engineering
Second Reader: David C. Jenn, Department of Electrical and Computer Engineering**

This thesis investigates and demonstrates the workability of the time-reversed process for radar imaging applications, particularly, for bi-static or multi-static radars. One benefit of the time-reversed process is its ability to reduce the calculation to determine the targets' shape. The finite-difference-time-domain (FDTD) method is used to demonstrate the time-reversed process.

THESIS ABSTRACTS

Following an overview and description of the principles of the time-reversed process, the FDTD method is applied to the wave equation and the time reversed-process in 2-D space. The FDTD numerical model is developed and used for producing fundamental examples on conducting targets. The examples reveal that the time-reversed process can be employed for radar imaging within certain constraints. Finally, conclusions regarding the time-reversed-process are presented and recommendations for future research are provided.

DoD KEY TECHNOLOGY AREAS: Sensors, Modeling and Simulation

KEYWORDS: Time-Reversed Electromagnetics, Finite-Difference-Time-Domain, FDTD, Radar Targeting Imaging

IMPLEMENTING THE CROSS AMBIGUITY FUNCTION AND GENERATING GEOMETRY-SPECIFIC SIGNALS

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Master of Science in Electrical Engineering-September 2001

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Second Reader: Ralph D. Hippenstiel, Department of Electrical and Computer Engineering

The first purpose of this thesis is to implement an efficient Cross Ambiguity Function (CAF) algorithm to compute the Time Difference of Arrival (TDOA) and Frequency Difference of Arrival (FDOA) between two sampled signals. Two CAF-related MATLAB functions were written and analyzed. One implements a "coarse" mode and a "fine" mode to accurately compute the TDOA and FDOA. The second plots different views of the resulting three-dimensional CAF surface.

The second purpose is to develop a program to generate geometry-specific signals. Some software packages can artificially embed constant TDOAs and FDOAs between two signals. In real-world emitter-collector geometries (one emitter and two separate collectors), however, movement of the emitter and/or collectors causes time-varying TDOAs and FDOAs. A MATLAB function was written to generate pairs of Binary-Phase-Shift-Keying signals according to user-defined signal parameters and Cartesian geometries. The resulting signal pairs have realistic TDOAs and FDOAs that vary with time according to geometry and relative motion.

Several signal pairs with different geometries are generated and input into the CAF functions, and the results are compared with theoretical TDOA and FDOA calculations. Finally, signals with low signal-to-noise ratios are generated to evaluate the CAF's ability to find Low Probability of Detection signals.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Signals Intelligence, Geometry-Specific Signals

RADIATION EFFECTS ON InGaAs p-i-n PHOTODIODES

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Advisors: Todd R. Weatherford, Department of Electrical and Computer Engineering

James Luscombe, Department of Physics

This thesis identifies, characterizes, and identifies a method to predict the dark current degradation of InGaAs p-i-n Photodiodes caused by exposure to 55 MeV protons, 12 MeV protons, and 90 MeV electrons. Experimental proton and electron fluence levels (particles/cm²) were calculated and correlated to fluence levels for a 1 MeV neutron in silicon by equating the amount of physical damage incurred within the device. Physical damage was quantified as a displacement damage dose (Dd), which is simply the fluence level multiplied by the appropriate value for the material's non-ionizing energy loss (NIEL). Photodiodes were then irradiated and dark current data was collected. The resulting data were fitted into the three-term

THESIS ABSTRACTS

diode equation, and current coefficients were obtained. Proton data were used to document device performance, and to examine the relationship between fluence levels and changes in the current coefficients. Additionally, these data were used to verify that it is appropriate to use NIEL and Dd for the correlation of 55 MeV and 12 MeV protons. Electron data were also used to document device performance, but failed to demonstrate the ability of NIEL and Dd to accurately match the predicted changes in device performance caused by 90 MeV electrons and 55 MeV protons.

DoD KEY TECHNOLOGY AREA: Electronics, Other (Radiation Effects)

KEYWORDS: Radiation, InGaAs Photodetectors

ANALYSIS OF INTEL IA-64 PROCESSOR SUPPORT FOR A SECURE VIRTUAL MACHINE MONITOR

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B.S., Turkish Naval Academy, 1995

Master of Science in Electrical Engineering-March 2001

Advisor: Cynthia Irvine, Department of Computer Science

Second Reader: Frederick W. Terman, Department of Electrical and Computer Engineering

This thesis explores the Intel IA-64 architecture's capability to support a secure virtual machine monitor. The major mission of a virtual machine monitor is to provide an execution environment identical to the real machine environment for virtual machines. A VMM duplicates the real resources of a processor for virtual machines while making a virtual machine think that it is running on a real machine. As a result, a virtual machine monitor allows multiple virtual machines to run concurrently on the same machine.

A secure VMM on the Intel IA-64 architecture would offer several benefits. A secure VMM would ensure that security policy is enforced by constraining information flow between the supported virtual machines. This would provide PC users with a more secure environment in which to run COTS operating systems.

The Intel IA-64 architecture was analyzed to determine if it is virtualizable. Three types of virtual machine monitors and their hardware requirements have been defined. The IA-64 architecture was mapped to these hardware requirements. Analysis showed that the IA-64 architecture meets three main hardware requirements. However, IA-64 instruction set contains 18 sensitive unprivileged instructions. These instructions prevent the IA-64 architecture from being used for a Type I VMM. Several virtualization techniques used in some architectures are discussed to determine if these techniques could be applicable to virtualization of the IA-64 architecture.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Virtual Machines, Virtual Machine Monitors, Intel IA-64 Architecture

THE NPS VIRTUAL THERMAL IMAGE PROCESSING MODEL

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Master of Science in Systems Engineering-September 2001

Advisors: Alfred W. Cooper, Department of Physics

Ronald J. Pieper, Department of Electrical and Computer Engineering

A new virtual thermal image-processing model that has been developed at the Naval Postgraduate School is introduced in this thesis. This visualization program is based on an earlier work, the Visibility MRTD model, which is focused on predicting the minimum resolvable temperature difference (MRTD). The MRTD is a standard performance measure for forward-looking infrared (FLIR) imaging systems. It takes into account thermal imaging system modeling concerns, such as modulation transfer functions (MTFs), sampling, aliasing and noise, and provides virtual visual images that are associated with the thermal imaging system being modeled. This capability of the model allows the user to virtually evaluate the effects

THESIS ABSTRACTS

of component variation, noise, sampling and aliasing on the final four-bar image. The analysis demonstrated that aliasing effects in thermal images of four-bar patterns cannot, in general, be adequately modeled as noise. For example, the simulation experiments showed that under the right conditions aliasing can create a noticeable contrast enhancement in the output images.

DoD KEY TECHNOLOGY AREAS: Sensors, Modeling and Simulation

KEYWORDS: Thermal Image-Processing Model, Visibility MRTD, Minimum Resolvable Temperature Difference, MRTD

ANALYSIS OF M-JPEG VIDEO OVER AN ATM NETWORK

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Master of Science in Electrical Engineering-June 2001

Advisor: John McEachen, Department of Electrical and Computer Engineering

Second Reader: Murali Tummala, Department of Electrical and Computer Engineering

With the emergence of a network-centric philosophy of military operations, the behavior of video applications over resource-constrained information networks is of increasing interest in the development of future naval information systems. This thesis analyzes the impact of compression, delay variance, and channel noise on perceived networked video quality using commercially available off-the-shelf equipment and software. An experimental packet video laboratory is developed for quantitative and qualitative analysis of Motion JPEG video transmitted over a constrained Asynchronous Transfer Mode (ATM) network. Bandwidth profile analysis for various types of video points out the impracticality of ATM bandwidth and cell delay management algorithms for mainstream video applications such as entertainment and distance learning. Additionally, functional limitations of individual laboratory components are identified for consideration in the planning of future experimental work.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communication

KEYWORDS: ATM, Protocol, Motion JPEG, Packet Video, Communications

VLSI DESIGN OF SINE/COSINE LOOKUP TABLE FOR USE WITH DIGITAL IMAGE SYNTHESIZER ASIC

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Master of Science in Electrical Engineering-June 2001

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Phillip E. Pace, Department of Electrical and Computer Engineering

This thesis documents the circuit design, simulation, and integrated circuit mask layout of the sine/cosine Lookup Table (LUT) to be integrated into the Digital Image Synthesizer (DIS) ASIC. The DIS is a single-chip false target radar image generator to be used in countering wide-band imaging radars. The purpose of the LUT is to take the 5-bit input from the phase rotation adder of the DIS and digitally generate the In-phase (I) and Quadrature (Q) signals to form the false target radar returns.

The first part of the design includes an extensive analysis to determine the optimal resolution for the LUT ROM. The design proceeds with the circuit design of an 8-bit resolution sine/cosine LUT. SPICE Net-lists are generated from the circuit schematics in order to run simulations to prove logic validity and determine time delays. Mask layout of the verified design is constructed using a CMOS 0.18 micron process utilizing deep sub-micron technology. Finally, the mask layout design is verified by ensuring all design rule checks (DRCs) and layout versus schematic (LVS) checks are satisfied. In addition, recommendations are provided to assist other DIS project members in effectively using the aforementioned layout process in the continuing design and layout of the DIS ASIC.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREAS: Electronics, Electronic Warfare

KEYWORDS: Digital Image Synthesizer, VLSI, ASIC, CMOS, Lookup Table, ROM, Chip Design

AN INVARIANT DISPLAY STRATEGY FOR HYPERSPECTRAL IMAGERY

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B.S., Hellenic Naval Academy, 1991

Master of Science in Electrical Engineering-September 2001

Advisor: Roberto Cristi, Department of Electrical and Computer Engineering

Second Reader: Capt J. Scott Tyo, USAF, Department of Electrical and Computer Engineering

Remotely sensed data produced by hyperspectral imagers contains hundreds of contiguous narrow spectral bands at each spatial pixel. The substantial dimensionality and unique character of hyperspectral imagery requires display techniques that differ from those provided by traditional image analysis tools. This study investigated techniques enabling the display of hyperspectral images without the interference of in-scene characteristics that lead to biased representations depending on the content of every image under analysis. Utilizing the Principal Components Analysis transformation it is possible to simplify the representation requirements while maintaining the information contained in the scene. The introduction of an external eigenvector, containing few spectral characteristics, into the original scene data removes most of the spectral bias allowing for an accurate detection of the constituent elements. The subsequent shift of the resulting data to match the respective hue directions in the dataspace allows for image color fidelity based on the true composition of the image while all the environmental influence has been removed and the final outcome is readily perceived by the human vision.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Hyperspectral Imaging, Image Analysis

ANALYSIS OF MULTIRATE RANDOM SIGNALS

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Electrical Engineer-December 2000

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Committee Members: Roberto Cristi, Department of Electrical and Computer Engineering

Xiaoping Yun, Department of Electrical and Computer Engineering

Multirate digital signal processing techniques have been developed in recent years for a wide range of applications, such as speech and image compression, digital audio, statistical and adaptive signal processing, numerical solution of differential equations and many other fields.

The purpose of this thesis is to extend optimal filtering techniques to random signals sampled at different rates. In particular, two major problems are considered: (1) optimal filtering of two sets of observations at different sampling rates as a multirate Wiener filter, and (2) linear prediction on successive samples of a random process. In the first problem it is shown that the standard Wiener filter can be extended to the multirate case, while preserving its optimality. In the second problem it is shown that multichannel linear prediction on successive samples of a process, yields orthogonal uncorrelated innovations.

DoD KEY TECHNOLOGY AREAS: Electronics, Computing and Software, Sensors

KEYWORDS: Multirate Signal Analysis, Estimation, Wiener Filter

THESIS ABSTRACTS

TIME DELAY ESTIMATION FOR UNDERWATER SIGNALS AND APPLICATION TO LOCALIZATION

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Master of Science in Electrical Engineering-June 2001

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The problem of time difference of arrival (TDOA) is important in underwater acoustics for both passive and active sonar. Classical approaches to this problem are based on generalized cross-correlation (GCC) methods implemented in the frequency domain. After appropriate weighting of the cross spectral data in the frequency domain, an inverse discrete Fourier transform (IDFT) is performed and the peak of the resulting GCC function is located in the time domain.

This thesis shows that the cross-spectrum of the data satisfies an appropriate signal subspace model; therefore the IDFT can be replaced with a signal subspace technique such as MUSIC. The result is an enhanced ability to locate the peak. Further, application of methods such as root-MUSIC or ESPRIT produce direct numerical estimates for TDOA without the need to search for a peak. Results are presented for an extensive set of simulations using both synthetic signal data and data from a ocean acoustic propagation model (MMPE). Results are further presented for an application of the new method to target localization and tracking. In all cases results are compared using both the new methods and the classical methods.

DoD KEY TECHNOLOGY AREAS: Other (Underwater Acoustics, Signal Processing)

KEYWORDS: Time Difference of Arrival, Subspace Methods, Generalized Cross-Correlation, Localization

ULTRA-WIDEBAND, ANTENNA DESIGNS FOR MILITARY VEHICLE APPLICATIONS

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The commanding need to operate ultra-wideband communication systems in tactical environments, especially in military vehicle applications, will require efficient, omni-directional broadband antennas with a low profile. In the case of the LAV-C2 vehicles, the desired antenna should ideally operate from 30-450 MHz with a voltage standing-wave ratio (VSWR) of less than three across the entire band. Additionally, the antenna must be vertically polarized, must be constrained in size and must have a low profile. In this thesis, an antenna was designed that is capable of operating in the frequency range of 47-450+ MHz, covering the whole bandwidth for the AS-3588 monopole antenna and most of the bandwidth for the AS-3916 monopole (whip) antenna, which are both operating on the LAV-C2 vehicles. The antenna performance was optimized for its design restrictions. This thesis also examined the use of dielectric loading in order to minimize the antenna size relative to the operating wavelengths. The antenna was designed and its performance predicted using Ansoft's High-Frequency Structure Simulator (HFSS). The HFSS is based on the Finite-Element Method (FEM). As well, the HFSS assigns material properties, other than only metal, to a structure. This enabled more realistic antenna designs to be simulated. Several versions of the base design were modeled and simulated, and a comparison of their performance is presented.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Electronic Warfare, Modeling and Simulation

KEYWORDS: Ultra-Wideband Antenna, Omni-directional, Low Profile, Vertically Polarized, Ansoft High-Frequency Structure Simulator (HFSS), Dielectric Loading

MODELING TOTAL DOSE RADIATION EFFECTS IN A MULTI-EDGE SOI nMOSFET

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Silicon-On-Insulator (SOI) devices provide inherent radiation-hardness for dose-rate and single-event upset effects that makes them ideally suited for radiation environments such as space. Specifically, the SOI Metal-Oxide-Semiconductor Field Effect Transistor (MOSFET), with its many Si/SiO₂ interfaces, is normally only sensitive to total dose radiation effects. This thesis investigates how to model these effects accurately and develops a computer simulation methodology utilizing hole trapping for modeling total dose radiation effects in a SOI semiconductor device. Specifically, a commercial Technology Computer Aided Design (TCAD) application, modified to include total dose radiation effects, is used to simulate an irradiated n-channel, multi-edge SOI MOSFET. The accuracy of the model is evaluated by using the simulation data to calculate simplified radiation induced leakage currents at various radiation dosages and then comparing with experimental measured leakage currents from irradiated devices. Simulation results show that while hole trapping is a dominant mechanism in causing enhanced leakage current at lower dose levels, it cannot solely account for all the enhanced leakage that occurs in a multi-edge device at higher dose levels.

DoD KEY TECHNOLOGY AREAS: Electronics, Modeling and Simulation

KEYWORDS: Electronics, Silicon-on-Insulator (SOI), Modeling and Simulation, Radiation Hardened

MEETING SIGINT CONSTRAINTS IN PACKET TELEPHONY

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Second Reader: Douglas Fouts, Department of Electrical and Computer Engineering

An analysis of protocols and standards that govern Voice Over Internet Protocols (VOIP) is presented. Items of specific interest to the Intelligence Community and the Department of Defense are examined and discussed. Research efforts within the Intelligence Community are also detailed.

The recent expansion of Internet Protocol telephony industry completely changes voice service in the commercial communications environment. A forecast of VOIP expansion provides the Intelligence Community an insight into the challenges it faces. Finally, an analysis of identifiers in the field of major protocols is presented. This study concentrates on the H.323 protocol but also addresses the Media Gateway Control Protocol and the Session Initialization Protocol.

Major VoIP industry announcements are summarized. Internet telephony concepts, including a comparison of the major protocols, Internet Protocol telephony integration into networks, and Internet Protocol telephony services are reviewed. Using the information presented in this thesis, the Intelligence Community can gain understanding of VOIP information processing and how to leverage the technology in the emerging Information Age. The advantage that can be gained is vital to the warfighter and joint commanders as they face a different kind of adversary in the Twenty First Century.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications, Computing and Software, Other (Telecommunications)

KEYWORDS: Voice Over Internet Protocol, Signaling System 7, H.323, Public Switch Telephony Network, Internet Protocol

THE DESIGN, SIMULATION, AND FABRICATION OF A VLSI DIGITALLY PROGRAMMABLE GIC FILTER

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Master of Science in Electrical Engineering-December 2000

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In this research, the design, simulation and mask layout for a VLSI Digitally Programmable Generalized Impedance Converter (GIC) Filter is presented. Programmable elements are filter type (low-pass, high-pass, band-pass and notch), center frequency and quality factor. The analog design eliminates the quantization errors, analog-to-digital and digital-to-analog conversion components, and the processing time delay associated with digital signal processing devices. Using a GIC as the basic circuit simplifies topology changes to realize the programmability function and eliminates a problematic component for integrated circuit fabrication, the inductor. Additionally, switched capacitor usage allows the elimination of resistors from the design, another problematic component for integrated circuits. The design was simulated with PSPICE while VLSI mask layout was performed with LASI. The chip has been submitted for fabrication to further research the design of analog VLSI circuits.

DoD KEY TECHNOLOGY AREA: Electronics

KEYWORDS: GIC, Analog Filter, VLSI, Switched Capacitor, Programmable Filter

ULTRA-WIDEBAND, COMBAT WEARABLE INTEGRATED (COMWIN) ANTENNA DESIGN FOR THE JOINT TACTICAL RADIO SYSTEM (JTRS)

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The Ultra-Wideband, Combat Wearable Integrated (COMWIN) antenna is a 54 to 500 MHz antenna integrated into the protective flak vest worn by infantry Marines or soldiers. This COMWIN antenna was designed to support the Joint Tactical Radio System (JTRS), and is part of an antenna system developed at NPS that incorporates wideband antennas into combat equipment. The concealed design presented in this thesis would eliminate the traditional visual profile associated with radio operators in infantry units by eliminating the vertical whip antenna. In this thesis, a conformal vest antenna was designed with an approximate 10:1 bandwidth (54-500 MHz). The antenna's performance was predicted through computer simulation. A prototype was built and its performance was measured. Measurements on the prototype showed a good fit with the theoretical predications. The antenna's VSWR is less than 3:1 between 54 and 500 MHz. Simulation results at 54 MHz, 164 MHz, and 500MHz showed that the radiation patterns were omni-directional at lower frequencies and became more directional at higher frequencies, concentrated in the sector from the horizon to 60° elevation.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Communications, Antennas, COMWIN

THESIS ABSTRACTS

KALMAN FILTERING OF FDOA/TDOA MISSILE TRACKING SYSTEM

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Second Reader: David C. Jenn, Department of Electrical and Computer Engineering

The accuracy of a tracking system designed to determine the time, space and position information (TSPI) of an airborne missile by detecting its telemetry signal at a number of receiver sites is investigated. Doppler frequency measurements are converted to range differences between the missile and receiver sites, whose locations are known in three dimensions. An algorithm then utilizes these range differences to obtain the missile TSPI. The accuracy of the TSPI is a function of the measurement precision and the signal-to-noise ratio at the receiver sites.

This thesis examines the characteristics of the TSPI accuracy and investigates how a Kalman Filter can be used to enhance the accuracy of the TSPI.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Kalman Filter, Range Difference of Arrival (RDOA), Time Difference of Arrival (TDOA), Frequency Difference of Arrival (FDOA)

SHIPBOARD WIRELESS NETWORK APPLICATIONS

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Recently, the need to leverage technologies for better utilizing valuable personnel resources has become more important. Wireless Local Area Networks (WLANs) have been shown to be an enabling technology that allows companies in commercial industry to become more productive. Research has been conducted at the Naval Postgraduate School to determine how this technology can be utilized to help the Navy perform shipboard operations more efficiently.

Continuing the work of previous theses at NPS, the objective of this thesis is threefold. First, WLAN standards are examined. Second, laboratory tests are conducted to determine the performance of WLANs in which access points are configured as radio repeaters. Finally, a web-based application is developed for shipboard gage calibrations. The application automates major portion of gage calibration process by allowing technicians to submit and to view the calibration results using a web browser through wired or wireless LANs.

Testing results show that the access points from certain vendors are able to operate as radio repeaters and still provide adequate performance. Repeater functionality is not specified in IEEE 801.11 standards, and its implementation is vendor specific. Demonstration of the web-based gage calibration application shows that it is effective in improving calibration efficiency.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: IEEE 802.11, Wireless Local Area Network, Active Server Pages, Internet Database

THESIS ABSTRACTS

AN EXAMINATION OF POSSIBLE ATTACKS ON CISCO'S IPSEC-BASED VPN GATEWAYS

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Second Reader: John C. McEachen, II, Department of Electrical and Computer Engineering

Virtual Private Networks (VPNs) are an emerging security solution for computer networks in both the government and corporate arena. IPsec, the current standard for VPNs, offers a robust, standards-based, and cryptographically effective solution for VPN implementation. Because of the immense complexity of IPsec, effective analysis is difficult. In an environment where Information Warfare in general, and computer network attack in particular are becoming more pervasive, it is necessary conduct a critical, independent evaluation of IPsec from a security perspective.

In order to develop an effective evaluation of IPsec VPNs, a Cisco Systems IPsec-based VPN router network is used as an example. A detailed analysis of Cisco's IPsec-based implementation, as well as of the IPsec standard itself is conducted to determine what, if any, attacks or vulnerabilities exist in each.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Command, Control and Communications, Electronics, Electronic Warfare

KEYWORDS: Virtual Private Networks (VPN), Internet Protocol Security (IPsec), Computer Network Attack, Computer Security, Computing and Software, Network Security, Encapsulating Security Payload (ESP), Authentication Header (AH), Routers, Information Warfare (IW)

LOCALIZATION OF WIRELESS COMMUNICATION EMITTERS USING TIME DIFFERENCE OF ARRIVAL (TDOA) METHODS IN NOISY CHANNELS

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Master of Science in Systems Engineering-June 2001

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David C. Jenn, Department of Electrical and Computer Engineering

Tri T. Ha, Department of Electrical and Computer Engineering

The ability to provide position information of wireless emitters comprises a very important communication tool and has extremely valuable applications to military as well as civilian life. GSM is the most popular method of modulation adopted around the world, for mobile telephony. This thesis is focused on the Time Difference Of Arrival (TDOA) estimation, applied to GSM signals, in noisy channels. Improvements in denoising, in conjunction with wavelet processing, are proposed for estimating the TDOA of signals received at two spatially separated sensors. Wavelet denoising based on a modified maximum likelihood method and a higher order moment method is proposed, to improve the performance. A numerical evaluation of the methods, when unequal SNR conditions prevail, is presented. The performance of the proposed denoising methods in a jamming environment is also addressed. Simple excision schemes to improve the performance when jamming is present, are evaluated. Simulation results indicate good performance of the methods and improved estimates relative to the ones obtained using no denoising. Jamming presence degrades the performance but still the extracted estimates are improved.

DoD KEY TECHNOLOGY AREAS: Electronics, Electronic Warfare

KEYWORDS: Global System for Mobile (GSM), Time Difference Of Arrival (TDOA), Wavelet Denoising, Jamming, Emitters Localization

THESIS ABSTRACTS

PREDICTION OF WIRELESS COMMUNICATION SYSTEMS PERFORMANCE IN SHIPBOARD COMPARTMENTS IN THE 2.4 GHz ISM BAND

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A physical understanding and consequent mathematical modeling of RF energy in naval indoor environments is of vital importance to the usability and effectiveness of communication systems used by the Navy. Over the last few years, there is a growing interest in placing Wireless Local Area Networks (WLANs) in ships and submarines. Especially large ships yet to be constructed, are designed with increased electronic systems but limited personnel. Reliable electronic systems will be crucial for efficient ship operation and survivability.

This thesis investigates the feasibility of deploying a physical model called Numerical Electromagnetic Code-Basic Scattering Code (NEC-BSC) to simulate confined naval compartments in the 2.4 GHz Industrial Scientific Medical (ISM) band. More specifically, using NEC-BSC the coverage area, the number and positions of transmitters and observation points and the statistics of Radio Frequency (RF) signal distribution were described. The area specifically targeted for this research was a typical two-story missile room. Additionally, some important conclusions regarding the validity of NEC-BSC for indoor applications are presented and some recommendations for future research are provided.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Simulation of Signal Propagation, Indoor Radio Propagation, Typical Missile Room, NEC-BSC

QUALITY OF SERVICE ANALYSIS IN MOBILE AD-HOC NETWORKS

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This thesis proposes schemes to provide Quality of Service (QoS) in mobile ad-hoc networks (MANETs). To achieve QoS, independently of the routing protocol, each mobile node participating in the network must implement traffic conditioning, traffic marking and buffer management (Random Early Drop with in-out dropping) or queue scheduling (Priority Queuing) schemes. In MANETs, since the mobile nodes can have simultaneous multiple roles (ingress, interior and destination), it was found that traffic conditioning and marking must be implemented in all mobile nodes acting as source (ingress) nodes. Buffer management and queue scheduling schemes must be performed by all mobile nodes.

By utilizing the Network Simulator (NS2) tool, this thesis focused on the empirical performance evaluation of the QoS schemes for different types of traffic (FTP/TCP, CBR/UDP and VBR/UDP), geographical areas of different sizes and various mobility levels. Key metrics, such as throughput, end-to-end delay and packet loss rates, were used to measure the relative improvements of QoS-enabled traffic sessions. The results indicate that in the presence of congestion, service differentiation can be achieved under different scenarios and for different types of traffic, whenever a physical connection between two nodes is realizable.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: MANET, JTRS, NS2, DSR, QoS, RSVP, Diffserv

THESIS ABSTRACTS

EFFECTIVENESS OF MODELING A HIGH POWER RADIO FREQUENCY (HPRF) WEAPON SYSTEM (U)

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**Master of Science in Applied Physics-December 2000
and**

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Master of Science in Applied Physics-December 2000

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Donald Walters, Department of Physics

CAPT James R. Powell, USN, Information Warfare Academic Group

The objective of this research was to model the electromagnetic output of a proposed High Power Radio Frequency (HPRF) weapon system. The antenna data was generated using GNEC, a method of moments computational electromagnetic code. The impulsive excitation and resultant transient near-fields were modeled using electrical circuit analysis and inverse Fast Fourier Transformation programmed in MATLAB 5.3. The peak amplitudes and waveforms were the primary focus of this study.

DoD KEY TECHNOLOGY AREAS: Electronics Warfare, Directed Energy Weapons, Modeling and Simulation

KEYWORDS: Electronic Warfare, Directed Energy Weapons, Antenna Design, Antenna Modeling, Electromagnetic Simulation

THE DESIGN, SIMULATION, AND FABRICATION OF A BICMOS VLSI DIGITALLY PROGRAMMABLE GIC FILTER

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Second Reader: Douglas Fouts, Department of Electrical and Computer Engineering

This thesis used a previously designed programmable GIC filter as a basis in which to incorporate a BiCMOS operational amplifier. An NPN bipolar transistor layout was designed and incorporated into an opamp layout, which was a modified version of a CMOS-only design. The BiCMOS opamp was simulated using Silvaco SmartSpice and showed considerable improvement over its CMOS equivalent. Additional improvements were made to the GIC filter to include a passgate with reduced resistance, and a correction was made to the capacitor layout. Simulations were also performed on a switched-capacitor bilinear resistor and a switched-capacitor variable bilinear resistor. Results from the bilinear resistor simulations require further study and testing. Finally, a VLSI layout of the filter was accomplished using LASI and has been submitted to MOSIS for fabrication.

DoD KEY TECHNOLOGY AREAS: Electronics

KEYWORDS: GIC Filter, Silvaco SmartSpice

THESIS ABSTRACTS

VULNERABILITIES OF MULTIPROTOCOL LABEL SWITCHING

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Second Reader: Herschel H. Loomis, Department of Electrical and Computer Engineering

This thesis examines performance and security aspects of Multiprotocol Label Switching (MPLS). Specifically, behavior of the Resource Reservation Protocol for Traffic Engineering (RSVP-TE) and its use as a Label Distribution Protocol (LDP) is observed. Hypothetical vulnerabilities are developed through analysis of the protocols and tested using a simple network topology. Testing results and areas for future work are presented.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Modeling and Simulation, Computing and Software

KEYWORDS: Computer Networks, Multiprotocol Label Switching, MPLS, Vulnerabilities, Exploits

EXPLOITATION OF AN IEEE 802.11 STANDARD WIRELESS LOCAL AREA NETWORK THROUGH THE MEDIUM ACCESS CONTROL (MAC) LAYER

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Wireless Local Area Networks (WLAN) have increased in popularity and use in recent years and with this has come a respective increase in interest in ways to exploit these networks. Among the varying proprietary and standardized implementations available, the IEEE 802.11 standard WLAN has become the predominant implementation of WLAN in use today. This thesis examines the Medium Access Control (MAC) layer of the IEEE 802.11 WLAN for security weaknesses and vulnerabilities that can be exploited to eavesdrop, modify or inject data, or gain access to a WLAN. The functionality of the MAC layer in the IEEE 802.11 standard is reviewed and specific known attacks against it are presented and analyzed. Finally, a review of a current proposal to enhance the security of the IEEE 802.11 standard is presented.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Computing and Software, Other (Information Operations)

KEYWORDS: Wireless Local Area Networks, IEEE 802.11, Exploitation, Medium Access Control Layer, Cryptology, Network Security, Information Operations

COMBINED ADAPTIVE POWER-RATE CONTROL IN CDMA SYSTEMS

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In this thesis, combined power and rate adaptations in the reverse channel of a multicell CDMA cellular system over a Nakagami-Lognormal frequency selective fading channel are considered. Imperfect power control, user traffic distribution, Intracell interference, co-channel interference, a RAKE receiver and spatial diversity are also considered. Numerical results obtained by Monte Carlo simulation show that power and rate adaptations result in an increase of the system capacity and prolong the mobile station's battery life.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREAS: Electronics

KEYWORDS: CDMA Systems, Battery Life

DIGITAL LOW PROBABILITY OF INTERCEPT RADAR DETECTOR

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and

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The function of a Low Probability of Intercept (LPI) radar is to prevent its interception by an Electronic Support (ES) receiver. This objective is generally achieved through the use of a radar waveform that is mismatched to those waveforms for which an ES receiver is tuned. This allows the radar to achieve a processing gain, with respect to the ES receiver, that is equal to the time-bandwidth product of the radar waveform. This processing gain allows the LPI radar to overcome the range-squared advantage of the ES receiver in conventional situations. Consequently, a conventional ES receiver can only detect an LPI radar at very short ranges (<3 nm).

The focus of this thesis was to develop an ES receiver to detect LPI radar signals with the same sensitivity as conventional pulse signals. It implements a detector which employs a technique, known as "deramping," that forms an adaptive matched filter to the linear FMCW LPI radar signal in order to achieve the processing gain that is equal to the received signal's time-bandwidth product. An experimental transmitter was built to emulate the radar signal with FMCW characteristics and transmitted through a standard gain horn. The transmitted signal is then received via a receiver horn, mixed down to an intermediate frequency (IF), sampled by an A/D convertor and digitally deramped using a Pentium II computer.

It was demonstrated that the LPI radar signal can be extracted from the noise background by means of digital deramping.

DoD KEY TECHNOLOGY AREA: Electronic Warfare

KEYWORDS: FMCW, LPI, LPI Radar, Deramp, PILOT, Chirp, Frequency-modulated Continuous Wave

CAPABILITIES AND LIMITATIONS OF ORTHOGONAL FREQUENCY-DIVISION MULTIPLEXING IN WIRELESS APPLICATIONS

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Orthogonal frequency-division multiplexing (OFDM) is a transmission scheme that, unlike conventional transmission schemes that send only one signal at a time over one radio frequency, sends a high-speed signal concurrently on a number of different frequencies. This allows for a robust and efficient use of bandwidth. These characteristics make OFDM particularly suitable for wireless local area network communications that are susceptible to noise, interference and distortion. In this paper, concepts are introduced along with their applications to high speed data transmission. In addition, a technique to exploit OFDM systems, based on exploitation techniques for direct sequence spread spectrum systems, is developed.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREAS: Electronics

KEYWORDS: Wireless Applications, High-Speed Signal

ANGULAR RATE ESTIMATION FOR MULTI-BODY SPACECRAFT ATTITUDE CONTROL

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Aeronautical and Astronautical Engineer-June 2001

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Spacecraft with high performance attitude control systems requirements have traditionally relied on imperfect mechanical gyroscopes for primary attitude determination. Gyro bias errors are connected with a Kalman filter algorithm that uses updates from precise attitude sensors like star trackers. Gyroscopes, however, have a tendency to degrade or fail on orbit, becoming a life-limiting factor for many satellites. When errors become erratic, pointing accuracy may be lost during short star gaps. Unpredictable gyros degradations have impacted NASA spacecraft missions such as Skylab and Hubble Space Telescope as several DoD and ESA satellites. An alternative source of angular rate information is a software implemented real time dynamic model. Inputs to the model from internal sensors and known spacecraft parameters enable the tracking of total system angular momentum from which body rates can be determined. With this technique, the Kalman filter algorithm provides error corrections to the dynamic model. The accuracy of internal sensor and input parameters determine the effectiveness of this angular rate estimation technique. This thesis presents the background for understanding and implementation of the technique into a representative attitude determination system. The system is incorporated into an attitude simulation model developed in SIMULINK to evaluate the effects of dynamic modeling errors and sensor inaccuracies. Results are presented that indicate that real time dynamic modeling is an effective method of angular rate determination for maneuvering multi-body spacecraft attitude control systems.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Modeling and Simulation

KEYWORDS: Dynamic Gyro, Kalman Filter, Attitude Determination, Rate Estimation, Star Trackers, Attitude Simulation, Multi-body Dynamics, Quaternion, MATLAB, SIMULINK

PERFORMANCE ANALYSIS OF PILOT-AIDED FORWARD CDMA CELLULAR CHANNEL

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Jan E. Tighe, Department of Electrical and Computer Engineering

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In this thesis the performance of the forward channel of a DS-CDMA cellular system operating in a Rayleigh-fading, Lognormal-shadowing environment is analyzed. An upper bound on the probability of bit error, including all the participating interference is developed. In addition, various techniques such as sectoring and forward error correction in the terms of convolutional encoding are applied to optimize the performance. The performance is further improved by applying a narrow bandpass filter in the pilot tone branch of the demodulator. The bandwidth of the filter is then adjusted in the means of the interference power passing through and observe the effects on the probability of bit error of the system. Moreover, pilot tone power control is added to enhance the demodulation. Finally, in this thesis a simple single cell system functioning as a port-to-port network communication between very small numbers of users is analyzed.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREAS: Electronics

KEYWORDS: DS-CDMS Cellular System, CDMS Cellular Channel

ANALYSIS AND EVALUATION OF THE ELECTROMAGNETIC COMPATIBILITY OF COTS WIRELESS LAN COMPONENTS ONBOARD SUBMARINES

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Wireless Local Area Networks (WLANs) have become increasingly popular in recent years both in the civilian and military sectors. A series of theses have been produced at the Naval Postgraduate School to provide a Commercial-Off-The-Shelf (COTS) component WLAN system for the New Attack Submarine (NASN) Program. However, the environment of a submarine is a complicated, electromagnetically noisy place. The Electromagnetic Compatibility (EMC) standards regulating electromagnetic emissions and electromagnetic susceptibility differ greatly between the civilian and the military sectors. Any electromagnetic incompatibility between systems can be disruptive to their operation. A great deal of EMC analysis must be accomplished in order to introduce components from one regulatory world into another.

The goal of this thesis is to verify that the Aironet 4800 DS WLAN component suite meets the military regulatory standard with regard to electromagnetic compatibility for submarine systems. This verification was accomplished by first analyzing Federal Communication Commission EMC reports on the 4800 series components. The 4800 series then underwent several EMC tests mandated by the military standard governing EMC, MIL-STD-461E. CE102 and RE102 tests were conducted at the Naval Postgraduate School in Monterey, CA. CS101 and RS103 tests were conducted at the EMC laboratories of Electric Boat in Groton, CT. Each test is representative of one aspect of the EMC environment. Based on this limited testing of conducted emissions, radiated emissions, conducted susceptibility and radiated susceptibility, it appears that these commercial components meet the MIL-STD-461E standard with respect to submarines.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications

KEYWORDS: Wireless LAN, WLAN, Aironet 4800 DS WLAN, NASN Program

SENSITIVITY ANALYSIS OF AN OPTIMUM MULTI-COMPONENT AIRBORNE ELECTRONIC ATTACK CONFIGURATION FOR SUPPRESSION OF ENEMY AIR DEFENSE

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In response to the need to augment or replace the aging EA-6B Prowler, Integrated Product Teams (IPTs) are formed to conduct an Analysis of Alternatives (AoA) to define the operation requirements that address the Department of Defense's (DoD) Airborne Electronic Attack (AEA) need. This thesis is primarily concerned with determining an optimum multi-component command and control warfare/electronic attack (C2W/EA) configuration of assets including platform, jammer and receiver selection for the suppression of enemy air defense (SEAD). A sensitivity analysis of the solution evolved by simulation is performed in order to determine the robustness in the derived measures of effectiveness to system failures or variances in the performance parameters. The tasks involved with this effort include simulating the classified RT-4 distributed scenarios to baseline the corresponding measure of effectiveness (i.e., target engagement time by surface-to-air missile site). One or more parameters in the scenario solution are then changed (receiver

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dynamic range, jamming assignment, etc.) and the measures of effectiveness are rederived in order to investigate their sensitivity to these changes. In addition, this thesis develops a User's Guide for the Naval Research Laboratory (NRL) Advanced Reactive Electronic Warfare Simulation (ARES) software, Version 1.12, used in the analysis.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Command, Control, and Communications, Electronic Warfare, Sensors, Modeling and Simulation

KEYWORDS: Analysis of Alternatives, Airborne Electronic Attack, EA-6B, Suppression of Enemy Air Defense

SIMULATION OF AN ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING BASED UNDERWATER COMMUNICATION SYSTEM USING A PHYSICS BASED MODEL FOR THE UNDERWATER ACOUSTIC SOUND CHANNEL

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Master of Science in Engineering Science-September 2001

Advisors: Roberto Cristi, Department of Electrical and Computer Engineering

Kevin B. Smith, Department of Physics

The primary thrust of this thesis is the development of a computer-based simulation of an Orthogonal Frequency Division Multiplexing (OFDM) based underwater acoustic communication system. The product will support the testing and evaluation of various digital signal processing algorithms applicable to underwater acoustic communication systems using OFDM as well as the study of the effects of the acoustic channel and communication system factors on the key parameters of the system such as bit error rate, received signal to noise ratio, frequency band of employment and overall system bit rate. The underwater acoustic sound channel is modeled using a physics based parabolic equation approximation. The simulation models the key components in the transmitter and receiver that contribute to the overall performance of the system. The results of the thesis provide expected values for system performance in terms of bit rate, bit error rate and received SNR for given frequency bands and are validated through comparison to theoretically derived expectations and to ocean testing of OFDM underwater communication systems.

DoD KEY TECHNOLOGY AREAS: Electronics, Other (Underwater Acoustics)

KEYWORDS: Digital Signal Processing, Underwater Acoustic Communication System

EFFECTIVENESS OF THE EA-6B AIRCRAFT STAND-OFF JAMMING AGAINST THREAT AND EARLY WARNING RADAR DURING OPERATION ALLIED FORCE IN SERBIA, AND OPERATIONS NORTHERN AND SOUTHERN WATCH IN IRAQ

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Master of Science in Electrical Engineering-June 2001

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This thesis addresses the jamming effectiveness of electronic attack (EA) operations of the EA-6B against early warning (EW) and threat radar during Operation ALLIED FORCE (OAF) from March-June 1999 and Operations NORTHERN WATCH (ONW) and SOUTHERN WATCH (OSW) from July-August 2000. Effectiveness was determined by examining confirmation from all-source intelligence regarding events where jamming was used against targeted radar to degrade their detectability or tracking of strike aircraft. In the absence of confirmation data, the EA-targeting effectiveness was resolved by modeling individual EA-targeting incidents and analyzing whether striker aircraft were protected from enemy radar. In-depth analysis of EA-6B incidents were selected based on the post-mission reports from the EA-6B, strike

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aircraft, and other reconnaissance and surveillance sources. For OAF, ONW, and OSW, 20 EA-6B incidents were modeled for in-depth analysis. The limited sample size and the inability to always correlate all-source intelligence to an event timeframe impacted the results. The Improved Many-on-Many (IMOM) model was used to model the radar and Tactical Jamming System. The conclusions were based on the post-incident mission analysis, all-source intelligence correlation to an incident recreation, and the theoretical calculation of expected jamming effectiveness against radar systems.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare

KEYWORDS: EA-6B, AN/ALQ-99, Tactical Jamming System, Air War Over Serbia (AWOS), Operation ALLIED FORCE (OAF), Operation NORTHERN WATCH (ONW), Operation SOUTHERN WATCH (OSW), Serbia, Iraq, Electronic Attack, Targeting

EXPERIMENTAL USE OF THE LAWRENCE LIVERMORE DEVELOPED MICRO-POWER SHORT PULSE RADAR TO EXTRACT LOW AMPLITUDE MODULATION SIGNALS CORRESPONDING TO HUMAN HEART RATES

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Master of Science in Applied Physics-September 2001

Advisor: Capt J. Scott Tyo, USAF, Department of Electrical and Computer Engineering

Second Reader: Richard M. Harkins, Department of Physics

Detecting a living person buried in rubble or concealed in buildings has far reaching search and rescue as well as military applications. This thesis developed a filter from a catalog of close range impulse response signals that were acquired using Micro-power Short Pulse Radar developed at Lawrence Livermore National Laboratory.

Utilizing matched filtering techniques, low amplitude modulations signals corresponding to the human heart were extracted from return signals out to 40 feet. Human heart signals were extracted from return signals in air and through different materials. The matched filter output of the signal compared with the noise was then used to develop detection probabilities and performance characteristics based on range and material.

DoD KEY TECHNOLOGY AREAS: Electronics

KEYWORDS: Close Range Impulse Response Signals, Micro-Power Short Pulse Radar, Human Heart Signals

MODELING THE EFFECTS OF GPS JAMMING ON A THEATER CAMPAIGN

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Master of Science in Space Systems Operations-September 2001

Advisor: Charlie Racoosin, Naval Space Systems Academic Chair Professor

Second Reader: John Van Hise, Jr., Department of Electrical and Computer Engineering

This study reviews the manner in which four precision-guided weapons utilize the NAVSTAR Global Positioning System (GPS) to increase their accuracy, and threats to GPS that may be employed to reduce their accuracy. The study incorporates a Navy-approved Modeling and Simulation (M&S) program to modify weapons parameters affected by GPS. The M&S system is used to simulate a large-scale theater campaign, based upon actual war plans. The results of the simulation scenario are used to evaluate possible threats to GPS guided weapons and to highlight thought processes that military planners may need to consider when operating in a GPS-denied or GPS-degraded electronic warfare environment.

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DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Electronic Warfare

KEYWORDS: NAVSTAR GPS, GPS Jamming, Weapons Parameters

SPACE TRAINING AND EDUCATION FOR USN CRYPTOLOGIC OFFICERS - THE ROAD TO SPACE CERTIFICATION

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M.S., Johns Hopkins University, 1997

Master of Science in Space Systems Operations-September 2001

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John W. Van Hise Jr., Department of Electrical and Computer Engineering

This thesis discusses the importance of space-related education and training for Naval cryptologic officers in their efforts to support the warfighter. It includes a discussion of the learning continuum concept, an outline of cryptologic officer's career milestones for space-related training, and a discussion of the Navy's Distributed Learning initiatives. This thesis provides a framework for the establishment of a Space

Certification Program for Naval cryptologists. The proposed Space Certification model was designed to allow expansion of the program to include Naval officers in other communities.

DoD KEY TECHNOLOGY AREAS: Manpower, Personnel and Training

KEYWORDS: Space Training and Education, Cryptologic Officers, Distributed Learning Initiatives

VULNERABILITY ASSESSMENT OF WIRELESS DATA NETWORK SIGNAL TRANSMISSIONS

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Master of Science in Systems Technology-June 2001

Advisor: Tri T. Ha, Department of Electrical and Computer Engineering

Second Reader: Dan C. Boger, Command, Control, Communications, Computers, and Intelligence Academic Group

The abstract is for official use only.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Wireless LAN, Wireless Bridge, IEEE 802.11, IEEE 802.16

DEFINING AND VALIDATING A COVERT ANALYSIS DETECTION (CAD) SYSTEM AND ITS STEALTHY DATA CAPTURE, CONTROL AND ANALYSIS CAPABILITIES

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Dan Boger, Information Systems Academic Group

A Covert Analysis Detection (CAD) system is an operationalized honeypot or honeynet that is designed to covertly capture, control and provide analysis capabilities of all traffic that flows through it. It was found that the covert data capture capability not only revealed the attackers tools (captured as source code) and tactics (collection of compromised systems), but also over time it revealed that that attacker's actual motive was the creation of a distributed denial of service (DDoS) network. The discovery of this lethal network

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tool and all the signatures of its creation and maintenance, proved the validity of the CAD's capabilities to aid in the enhancement of our information protection resources.

DoD KEY TECHNOLOGY AREA: Command, Control and Communications, Computing and Software

KEYWORDS: Network Security, Information Protection, Intrusion Detection, Deception, Deterrence, Honeypot, HoneyNet, Distributed denial of service (DDoS)

DESIGN AND PERFORMANCE ANALYSIS OF AN ASYNCHRONOUS PIPELINED MULTIPLIER WITH COMPARISON TO SYNCHRONOUS IMPLEMENTATION

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Master of Science in Electrical Engineering-December 2000

**Advisors: Douglas J. Fouts, Department of Electrical and Computer Engineering
Herschel H. Loomis, Jr., Department of Electrical and Computer Engineering**

Synchronous techniques have dominated digital logic system design for decades because they are well understood and less complicated to implement. With the advent of more exotic high-speed transistors, the issues of clock skew, system performance, power consumption, and technology migration become critical to synchronous system designers. Asynchronous digital design techniques utilize a local completion signal or request/acknowledge handshake to lend the stability afforded by the global clock in synchronous systems. This research evaluates a moderately complex digital system, an 8x8-bit multiplier utilizing high speed Indium Phosphide heterostructure bipolar junction transistors, to determine whether asynchronous logic design can compete with synchronous design in terms of system speed and power consumption. Theoretical timing equations are developed that relate the relative merits of each technique for input-to-output latency and system throughput. Tanner SPICE simulation tools are used to evaluate the full 8x8-bit asynchronous array multiplier. Finally, direct comparisons are made between five separate pipelined configurations of the multiplier utilizing both synchronous and asynchronous timing methodologies. As integrated circuits become smaller, faster, and more complex, asynchronous schemes will continue to mature and become more prevalent in digital system design.

DoD KEY TECHNOLOGY AREA: Electronics

KEYWORDS: Asynchronous Logic, Pipelined Logic, Micropipelines

WEB-BASED TEACHING AND LEARNING OF ELECTRICAL ENGINEERING COURSES

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Master of Science in Electrical Engineering-March 2001

**Advisor: Jon T. Butler, Department of Electrical and Computer Engineering
Second Reader: Herschel H. Loomis, Department of Electrical and Computer Engineering**

This thesis describes the design of an interactive Web-based course, namely EC4810 Fault Tolerant Computing, taught in the Department of Electrical and Computer Engineering (ECE), at the Naval Postgraduate School. It is part of the ECE Department's Distributed Learning program in which students will use multimedia enhanced online courses through the Web. A major accomplishment of this thesis is the development of a template for other courses. A step-by-step guide has been developed that outlines the process of online course maintenance and procedures for producing other courses.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Web-Based Learning, Multimedia, On-Line Course

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DEVELOPMENT, SIMULATION AND EVALUATION OF THE IEEE 802.11a PHYSICAL LAYER IN A MULTIPATH ENVIRONMENT

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Second Reader: Xiaoping Yun, Department of Electrical and Computer Engineering

This thesis describes the development of a simulation of the newly proposed IEEE 802.11a physical layer and demonstrates the effects of Additive White Gaussian Noise (AWGN) and multipath on its performances. The IEEE 802.11a standardization group has selected Orthogonal Frequency Division Multiplexing (OFDM) as the basis for the new 5 GHz standard, targeting a range of data rates from 6 up to 54 Mbps.

Coded OFDM (COFDM) is a channel coding and modulation scheme which mitigates the adverse effects of fading by using wideband multicarrier modulation combined with time interleaving and a convolutional error correcting code. A guard interval is inserted at the transition between successive symbols to absorb the intersymbol interference created by the time domain spread of the mobile radio channel. The decoding process is performed using differential demodulation in conjunction with a hard decision Viterbi decoder.

The simulation results showed that COFDM system is capable of indoor environment communications in the presence of known multipath and noise conditions. The results obtained also showed that the COFDM configuration is immune to Doppler shift of 5 to 15 Hz.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Coded Orthogonal Frequency Division Multiplexing (COFDM), MATLAB, Convolutional Encoding, Viterbi Decoder, Interleaver, Multipath, Additive White Gaussian Noise (AWGN), Inverse Fast Fourier Transform (IFFT), Guard Interval

SIMULATION AND PERFORMANCE ANALYSIS OF THE AD HOC ON-DEMAND DISTANCE VECTOR ROUTING PROTOCOL FOR TACTICAL MOBILE AD HOC NETWORKS

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Advisor: Murali Tummala, Department of Electrical and Computer Engineering

Second Reader: Robert Ives, Department of Electrical and Computer Engineering

This thesis presents a simulation and analysis of the Ad Hoc On-Demand Distance Vector Routing Protocol (AODV) for mobile ad hoc network (MANET) environments using the Network Simulator 2 (NS2) tool. AODV is being suggested for possible implementation in the Joint Tactical Radio System (JTRS) for the United States military. Utilizing an AODV model resident in NS2, the simulation focuses on key performance parameters that include the packet delivery fraction, routing loss, buffer loss, total loss, throughput and goodput. The AODV node movement and traffic connection files have been generated to measure the network performance for a given environment using specific parameters. The results reported in this thesis indicate that the network environment size, packet rate and offered load are critical to the network performance. Node velocity played a minimal role in affecting the overall network performance.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communication, Computing and Software, Modeling and Simulation

KEYWORDS: Joint Tactical Radio System, Mobile Ad Hoc Network, Network Simulator 2, Protocol Analysis, Ad Hoc On-Demand Distance Vector Routing

THESIS ABSTRACTS

A 3D PARABOLIC EQUATION (PE) BASED TECHNIQUE FOR PREDICTING PROPAGATION PATH LOSS IN AN URBAN AREA

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Electrical Engineer-September 2001

Advisors: Ramakrishna Janaswamy, Department of Electrical and Computer Engineering

David Jenn, Department of Electrical and Computer Engineering

Tri Ha, Department of Electrical and Computer Engineering

A mobile radio environment places fundamental limitations on the performance of wireless communication systems. Most models developed to predict propagation path loss have been historically performed in a statistical approach. These models are expensive to develop and do not offer the accuracy, computational advantages, and sufficiency as the parabolic equation (PE). The goal of this thesis is to develop a 3D model based on PE for predicting propagation path loss in urban areas on flat and hilly terrains. The PE method offers the computational advantages, where one can approximate the elliptic operator governing the true wave behavior by a much simpler parabolic operator that permits marching in range. Moreover those all-important aspects of propagation such as reflection and diffraction are included automatically in the formulation. Four test problems on flat terrain and two test problems on hilly terrain will be simulated. For the flat terrain, the 3D PE model results will be compared with the two-ray, the four-ray, the UTD, and the numerical integration technique results. For the hilly terrain, the results of the 3D PE model will be compared with the UTD and the numerical integration technique results.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Electronic Warfare

KEYWORDS: Wireless Communication Systems, Propagation Path Loss

MODELING AND ANALYSIS OF CELLULAR CDMA FORWARD CHANNEL

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Doctor of Philosophy in Electrical Engineering-March 2001

Master of Science in Applied Mathematics-March 2001

Advisor: Tri T. Ha, Department of Electrical and Computer Engineering

In this thesis, the forward channel model for a DS-CDMA cellular system operating in a slow-flat Rayleigh fading and lognormal shadowing environment is developed, which incorporates the extended Hata model to predict median path loss. Forward error correction is integrated into the model by applying convolution encoding with soft-decision decoding. The worst-case probability of bit error for a mobile user at the edge of the center cell of a seven-cell cluster is developed using Gaussian approximation. In estimating the probability of bit error, a statistical model is developed which approximates the sum of d multiplicative chi-square (two degrees of freedom)-lognormal random variables as a multiplicative chi-square (with $2d$ degrees of freedom)-lognormal random variable. Using this approximation, the performance of the cellular system is examined under a range of shadowing conditions, for various user capacities and with antenna sectoring as they compare with Monte Carlo simulated results. Next, our worst-case performance analysis is modified to accommodate users that are distributed in the cell according to a specified distribution and compare results with the worst-case performance. Finally, a fast power control is introduced into the forward channel and explore system performance with power control under a range of operating conditions as it compares with the fixed-power performance.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Modeling and Simulation

KEYWORDS: CDMA, Wireless, Performance Analysis, Rayleigh Fading, Lognormal Shadowing, Walsh Functions, Hata Model, Convolutional Codes, User Distribution, Power Control, Sum Distribution, Gaussian Approximation, Forward Channel Model, Antenna Sectoring

THESIS ABSTRACTS

MODELING AND PERFORMANCE ANALYSIS OF CELLULAR CDMA CHANNEL WITH RAKE RECEIVER

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Master of Science in Electrical Engineering-September 2001

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Jan E. Tighe, Department of Electrical and Computer Engineering

In this thesis, a cellular CDMA reverse channel model was established which incorporates a time-invariant discrete multipath Nakagami-fading channel in a multiple-cell system. The effects of intra and inter-cell interference, perfect power control, lognormal shadowing and RAKE receiver with varying number of taps are investigated. For performance improvement forward error correction and smart antenna techniques are incorporated into the model. Expressions for probability of bit error are developed under a range of operating conditions and the model is tested using Monte Carlo Simulation.

DoD KEY TECHNOLOGY AREAS: Electronics

KEYWORDS: CDMA Reverse Channel Model, RAKE Receiver

ANALYSIS OF INTEL IA-64 PROCESSOR SUPPORT FOR SECURE SYSTEMS

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Master of Science in Electrical Engineering-March 2001

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Second Reader: Frederick W. Terman, Department of Electrical and Computer Engineering

Current architectures typically focus on the software-based protection mechanisms rather than hardware for providing protection. In fact, hardware security mechanisms can be critical for the construction of a secure system. If hardware security mechanisms are properly utilized in a system, security policy enforcement can be simplified. Systems could be constructed for which serious security threats would be eliminated.

This thesis explores the Intel IA-64 processor's hardware support and its relationship to software for building a secure system. To analyze the support provided by the architecture, hardware protection mechanisms were examined. This analysis focused on the following mechanisms: privilege levels, access rights, region identifiers and protection key registers. Since protection checks are made through the translation lookaside buffer (TLB) during the virtual-to-physical translations, the TLB structure was an area of focus throughout the research for this thesis.

Proper use of the TLB-based hardware protection features permits protection in the IA-64 architecture. It enables the processor hardware and the operating system to collaborate to enforce security policies efficiently.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Protection, Intel IA-64 architecture, Secure Systems

BANDWIDTH REQUIREMENTS FOR THE ADVANCED AMPHIBIOUS ASSAULT VEHICLE (AAAV) COMMAND VARIANT

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The goal of this thesis is to identify the bandwidth requirements for the command variant of the Advanced Amphibious Assault Vehicle (AAAV). The work focuses on the network established to support an infantry

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battalion COC. At the center of this network will be the AAAV(C). All higher and subordinate communications links that connect directly with the AAAV(C) are modeled. The intent is to identify all traffic received and transmitted through the AAAV(C). Current systems are not discussed, as this study is intended to be independent of current system characteristics. The model is based on Internet Protocols (IP), with all communications, including voice and video, routed via IP addresses. This model attempts to provide better fidelity for future requirements analysis. Data on message size and transmission interval are identified that will allow grouping and analysis of message sets for future systems. Doctrinal messages appropriate for each node (unit) are identified and each message is then assigned a size (bits), and a transmission interval (minutes). Using a maneuver ashore scenario, network traffic flows for a 24-hour period are modeled with the software simulation tool Extend(tm). The model is then optimized and the minimum bandwidth required to support the scenario is identified.

DoD KEY TECHNOLOGY AREAS: Electronics, Command, Control and Communications

KEYWORDS: Advanced Amphibious Assault Vehicles, AAAV, Communications

DESIGN AND IMPLEMENTATION OF A HIGH-POWER RESONANT DC-DC CONVERTER MODULE FOR A REDUCED-SCALE PROTOTYPE INTEGRATED POWER SYSTEM

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Electrical Engineer-September 2001**

**Advisors: Robert W. Ashton, Department of Electrical and Computer Engineering
John G. Ciezki, Department of Electrical and Computer Engineering
Todd R. Weatherford, Department of Electrical and Computer Engineering**

An Integrated Power System (IPS) with a DC Zonal Electrical Distribution System (DCZEDS) is a strong candidate for the next generation submarine and surface ship. To study the implementation of an IPS with DCZEDS, members of the Energy Sources Analysis Consortium (ESAC) are currently constructing a reduced-scale laboratory. One fundamental component of DCZEDS is the Ships Service Converter Module (SSCM), commonly known as a buck DC-DC converter. This thesis documents the design, simulation, construction and testing of a 500V/400V, 8kW resonant soft-switched DC-DC converter. In theory, resonant converters will operate more efficiently and generate less Electromagnetic Interference (EMI) when compared to a standard hard-switched converter. In this thesis, the resonant converter is tested and compared to a hard-switched DC-DC converter that was designed for ESAC's reduced-scaled IPS. The results verify that the resonant DC-DC converter realizes significant efficiency and EMI generation improvements over the hard-switched converter at the cost of a more complex control system and power section.

DoD KEY TECHNOLOGY AREAS: Surface/Under Surface Vehicle-Ship and Watercraft, Electronics

KEYWORDS: Integrated Power System, Ships Service Converter Module, DC-DC Converter, DC Zonal Electrical Distribution System, DCZEDS

DETECTION AND FEATURE EXTRACTION OF MINE-LIKE OBJECTS FROM SEISMIC SONAR SIGNALS

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Master of Science in Electrical Engineering-March 2001

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Second Reader: Roberto Cristi, Department of Electrical and Computer Engineering**

This thesis investigates detection and classification issues when dealing with seismic signals and represents a first step in the direction of automated detection and classification of mine-like signals obtained using a seismic approach. A computationally cheap detection scheme that utilizes a combination of a simple

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combination of a short-term energy and zero-crossing detector is implemented and tested on five different classes of targets, resulting in a 100% detection rate for all non-natural targets and 33% detection rate of mine sized rock buried in sand.

Three feature extraction methods are evaluated for their possible use in a Gaussian Mixture Model classifier: higher order moments, pole extraction from impulse response modeling using the Steiglitz-McBride iteration, and Radial Basis Function Modeling of data. These methods demonstrate promising results for use in a classifier. However, only a very limited number of data trials per class was available in this work, and the proposed set-up needs to be further validated with additional data.

DoD KEY TECHNOLOGY AREAS: Sensors, Other (Mine Warfare)

KEYWORDS: Buried Mine Detection, Buried Mine Feature Extraction, Mine Warfare, Seismic Sonar, Mine Classification

CONCEPTS, APPLICATIONS AND ANALYSIS OF A SUBMARINE BASED WIRELESS NETWORK

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Master of Science in Computer Science-June 2001

Advisor: Xiaoping Yun, Department of Electrical and Computer Engineering

Second Reader: C. Thomas Wu, Department of Computer Science

As information technology tools continue to improve, we must take advantage of this wave by developing wise solutions to help automate many daily tasks presented onboard submarines. Java based applications and Commercial-off-the-Shelf (COTS) technology provides us low cost solutions that increase the availability and mobility of the information we seek. Small pen-based computers and wireless LANS allow us to create dynamic and distributable applications that can route paperwork or fight casualties. It is imperative we take full advantage of these technologies in the design of our new submarines as well as in retrofit of our older ones.

This thesis attempts to solve a key task, Damage Control (DC) communications, by designing a Java based application known as SWIPNet (Submarine Wireless Prototyped Network). This virtual grease board application uses multicast sockets to send standard DC and crew reports to all wireless handhelds that participate in a casualty. A proposed Virginia class wireless network, known as the Non Tactical Data Processing System (NTDPS), was then analyzed to determine network efficiency in the presence of SWIPNet and 14 other submarine type network loads. Demonstrations have proven that SWIPNet provides a more efficient way to communicate and can function effectively on the NTDPS.

DoD KEY TECHNOLOGY AREAS: Surface/Under Surface Vehicles - Ships and Watercraft, Computing and Software, Command, Control and Communications

KEYWORDS: Wireless Local Area Network, Mobile Computing, Java, Pen-Based Computing, Pdas, Handheld Computers, Database, OPNET Modeler, Microsoft Access, Damage Control, Multicast Sockets, Wireless Communications

ANALYSIS OF TRACKING AND IDENTIFICATION CHARACTERISTICS OF DIVERSE SYSTEMS AND DATA SOURCES FOR SENSOR FUSION

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Master of Science in Aeronautical Engineering-June 2001

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Gary Hutchins, Department of Electrical and Computer Engineering

In the Command and Control mission, new technologies such as 'sensor fusion' are designed to help reduce operator workload and increase situational awareness. This thesis explored the tracking characteristics of

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diverse sensors and sources of data and their contributions to a fused tactical picture. The fundamental building blocks of any sensor fusion algorithm are the tracking algorithms associated with each of the sensors on the sensor platform. In support of this study, the MATLAB program 'fusim' was written to provide acquisition managers a tool for evaluating tracking and sensor fusion algorithms.

The fusim program gives the user flexibility in selecting: sensor platforms, up to four sensors associated with that platform, the target types, the problem orientation, and the tracking algorithms to be used with the sensors. The fusim program was used to compare tracking algorithms in a multiple sensor/multiple target environment. Specifically, the Probabilistic Data Association Filter, the Interacting Multiple Models Filter, the Kalman Filter and the Constant Gain Kalman Filter were evaluated against multiple maneuvering, non-maneuvering, and fixed targets. It is recommended that this study be continued to evaluate advanced tracking and data association techniques, to expand the program to allow attribute tracking and identification, and to study the Human-Machine Interface aspects of sensor fusion.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Sensors, Command Control and Communications, Computing and Software

KEYWORDS: Data Fusion, Sensor Fusion, Tracking, Tracking Algorithms, Kalman Filter, Probabilistic Data Association, PDA, Interacting Multiple Models, IMM, Simulation

USING COMMERCIAL OFF-THE-SHELF DIGITAL SIGNAL PROCESSORS FOR RELIABLE SPACE BASED DIGITAL SIGNAL PROCESSING

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Alan A. Ross, Navy Tactical Exploitation of National Capabilities (TENCAP) Chair

A radiation tolerant testbed was designed using a Commercial-off-the-Shelf (COTS) Digital Signal Processor (DSP) and presented to prove the concept of Triple Modular Redundant (TMR) processors in order to make a COTS DSP radiation tolerant design. The system was designed to handle the effects of radiation associated with Single Event Upset only.

Two of the industry's leading programmable 32-bit floating-point digital signal processors were reviewed for this thesis, Analog Devices ADSP-21060 and the Texas Instruments TMS320C6701. The '6701 was the best processor for this design based upon size, power, speed, and tolerance to single event latchup, signal event burnout, and total ionization dose. A review of the processor's performance and characteristics is provided to ensure the proper operation of '6701 in a TMR design.

The system employs a bit by bit voter that compares the three processors' results and outputs the majority of the bits. All data, address, and control signals are monitored to determine that the system is operating properly. This system significantly differs from previous TMR designs, because only address errors cause immediate interrupts. Data errors cause processor interrupts only when the errors accumulate to a critical level. An external host processor controls the processors' shared memory space.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Electronics, Computing and Software

KEYWORDS: Fault-tolerant Computing, Digital Signal Processors, Texas Instruments TMS320C6701, Commercial-off-the-Shelf Technology, Radiation, Triple Modular Redundant, Analog Devices ADSP-21060

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MODELING JAMMING EFFECTS ON ROLLING AIRFRAME MISSILE

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B.S., Chinese Naval Academy, 1988

Master of Science in Systems Engineering-September 2001

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Second Reader: David C. Jenn, Department of Electrical and Computer Engineering

Development of countermeasures against infrared and optical guided missiles is enhanced by an ability to quantify the effects of the countermeasure. Analysts must be capable of accurately determining the attitude of the missile throughout its flight. This thesis describes the use of microelectronic-miniature (MEM) technologies to measure the strap down rates experienced by a rolling airframe missile and the model required to effectively determine the missile's attitude during its flight. The Tokin America CG-16D rate sensors and the Honeywell, SSEC, HMC 1002 roll sensor were used in an inertial measurement unit (IMU). The size of the IMU is small and rugged enough to be installed in a small diameter missile. A SIMULINK model is presented that performs the tasks of demodulating the sensors, performing coordinate transformation, and providing animation of the missile attitude for analysis. The model was evaluated for its ability to accurately determine the attitude of the missile based on input from the IMU packages. Sensor data was obtained from testing performed on a CARCO table flight motion simulator, and compared to the ground truth data provided by the CARCO table. Previous research had proved that this model worked for slow-spinning missile (5 Hz in roll). This thesis research expands that research to a fast spinning missile (15 Hz in roll). Through testing, the model was capable of providing solutions within the 2 degrees RMS requirement.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare

KEYWORDS: Jamming Effects, Microelectronic-Miniature, MEM, Countermeasures, Infrared and Optical Guided Missiles

MODELING SECOND GENERATION FLIR SENSOR DETECTION RECOGNITION AND IDENTIFICATION RANGE WITH POLARIZATION FILTERING

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Master of Science in Applied Physics-December 2000

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The influence of polarization filtering on maximum detection, recognition, and identification ranges of a generic second generation FLIR sensor is examined with a computational model. The scenario studied represents a second generation FLIR sensor mounted on an aircraft in level flight at 300m approaching a ship target. The target ship radiant signature is modeled with an advanced infrared signature prediction program, MuSES (Multi-Service Electro-Optic Signature). A weather file representative of Midlatitude Summer at sea conditions was utilized. Polarized sea background and path radiance calculations are performed with a polarized version of the SEARAD Radiance and Propagation Code. Results showed that there is an improvement in maximum range of the sensor for detection, recognition, and identification tasks when a horizontal filter is included, provided that the target does not have a negative degree of polarization. For detection task the improvements were found to be 33.48%, 35.65%, and 39.78% when the target has 0%, +2%, and +8% degree of polarization respectively. A better modeling of Apparent Temperature Difference (ATD) calculation is also developed. To improve the model use of polarized target model is recommended.

DoD KEY TECHNOLOGY AREAS: Sensors, Modeling and Simulation

KEYWORDS: Thermal Imaging Systems, Minimum Resolved Temperature Difference, Polarization Filters

THESIS ABSTRACTS

AIRBORNE EXPLOITATION OF AN IEEE 802.11B WIRELESS LOCAL AREA NETWORK

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B.S., Jacksonville University, 1993

Master of Science in Systems Engineering-September 2001

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Deployment of IEEE 802.11b wireless local area networks is increasing around the globe due to their cost compared to wired infrastructures, availability, versatility and recent performance gains in the areas of transmission speed. Coupled with its ease of implementation, IEEE 802.11b wireless local area networks provide a viable solution for convenient information access. Unfortunately, wireless LANs remain a new technology not fully understood by the organizations implementing them. IEEE 802.11b wireless local area networks are vulnerable to intrusion and exploitation due to its broadcast infrastructure. Adding a wireless network to an organization's internal LAN may open a potential backdoor into the existing wired network. This research investigates the feasibility of exploiting an IEEE 802.11b WLAN from an airborne platform for the purpose of gaining access into the backbone wired network. It explores the viability of exploiting the 802.11 standard through the Medium Access Control (MAC) Layer, looking at link analysis and the use of high-gain antennas and commercial-off-the-shelf (COTS) software to intercept and process these radio frequency signals. The research concludes with an evaluation of optimum flight profiles for intercepting and collecting IEEE 802.11b signals based on the performance in actual test flights.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare

KEYWORDS: IEEE 802.11B Wireless LAN, Wireless LAN

APPLICATION OF THE ROBUST SYMMETRICAL NUMBER SYSTEM TO HIGH RESOLUTION DIRECTION FINDING INTERFEROMETRY

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Master of Science in Applied Physics-December 2000

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This research has examined the benefits of using the Robust Symmetrical Number System (RSNS) to resolve ambiguities in phase sampling interferometry. A compact, high resolution direction finding antenna architecture based on the RSNS was developed to demonstrate experimentally the elimination of phase errors using a minimum amount of hardware. Previous work has determined that phase errors in the system will degrade the system performance. Several improvements were made to the original RSNS prototype antenna to provide enhanced performance. Adding isolators and supplementing the ground plane with copper tape (between the antenna elements), a reduction in the mutual coupling effects was accomplished. Mounting the microwave components on a brass plate also reduced errors contributed by vibrations and temperature. Tailor cutting all semi-rigid coaxial lines also helped reduce the number of connectors required to assemble the microwave circuit, also a source of phase errors. Matching the front-end amplifiers in each amplification stage rather than matching the characteristics of two cascaded amplifiers in each signal line has reduced relative phase errors between channels as well as matching the power outputs of the amplifiers. Two printed circuit boards were designed and built for the RSNS signal processor. The printed circuit boards provide a decrease in the electrical noise floor over the original design (assembled on breadboards). The new design has reduced the phase errors that were present in the first prototype system. The RSNS signal processing technique is able to provide a high-resolution phase sampled direction finding capability with an angular resolution of 1.9 degrees by using only three receiving elements (two interferometers).

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREAS: Sensors, Electronic Warfare

KEYWORDS: Robust Symmetrical Number Systems, Optimum Symmetrical Number Systems, Phase Sampling Interferometry, Direction Finding, Ambiguity Resolution

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